FINAL Environmental Statement
East-West Arterial Extension:
Section 2 (Woodland Drive – Lookout Road)
Section 3 (Lookout Road – Frank Sound Road)

NRA
NATIONAL ROADS AUTHORITY

April 29, 2025

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List of Terms and Symbology

AASHTO	American Association of State Highway and Transportation Officials
ac	Acre
ACR	Airport Collector Road
ADT	Average Daily Traffic
AMCB	Analysis of Monetised Costs & Benefits
AMI	Acute Myocardial Infarction
ATR	Automatic Traffic Recorder
Baird	W.F. Baird and Associates Coastal Engineers, Ltd.
BCR	Benefit/Cost Ratio
BRT	Bus Rapid Transit
BTW	Bobby Thompson Way
°C	Degree Celsius
CAPEX	Capital Expenditure
CBA	Cost-Benefit Analysis
CH_4	Methane
CI$	Cayman Islands Dollar
CIG	Cayman Islands Government
cm	Centimetre
CMW	Central Mangrove Wetland
CNE	Common Noise Environment
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CoS	Compendium of Statistics
CPI	Ministry of Commerce, Planning, and Infrastructure
CSF	Critical Success Factor
dBA	Decibels; A-Weighted Scale
DK/NS	Don't Know/Not Stated
DMRB	UK's Highways Agency Design Manual for Roads and Bridges
DoE	Department of Environment
EA	Enumeration Area
EAB	Environmental Assessment Board
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	United States Environmental Protection Agency
ERP	Environmental Resource Permit
ES	Environmental Statement
ESO	Economics and Statistics Office
ETH	Esterley Tibbetts Highway
EWA	East-West Arterial
EV	Electric vehicle
°F	Degree Fahrenheit

FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
ft	Foot/Feet
g/gal	Grams per gallons
g/hr	Grams per hour
g/veh-mi	Grams per vehicle mile
GBP	British Pounds
GCM	Grand Cayman Travel Demand Model
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information Systems
GNW	Godfrey Nixon Way
H&H	Hydrologic & Hydraulic
ha	Hectare
HCM	Highway Capacity Manual
hr	Hour
hr/day	Hours per day
HSA	Health Services Authority
HSM	Highway Safety Manual
IDF	Intensity-Duration-Frequency
IEMA	Institute of Environmental Management and Assessment
IFC	International Finance Corporation
in	Inch
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
km	Kilometre
km^2	Square kilometres
km/h	Kilometres per hour
L_{A10}	A-weighted, sound level, just exceeded for 10% of the measurement period
Leq	Equivalent Continuous Sound Level
LID	Low Impact Design or Development
LiDAR	Light Detection and Ranging
LOAEL	Lowest Observable Adverse Effect Level
LOD	Limits of Disturbance
LOS	Level of Service
LPH	Linford Pierson Highway
LTS	Level of Traffic Stress
m	Metre
m^3	Cubic metres
mi	Mile
mi^2	Square miles
mm	Millimetre
MOVES	Motor Vehicle Emission Simulator

mph	Miles per hour
MT	Metric Tonnes
MW	Megawatt
N_2O	Nitrous Oxide
NACTO	National Association of City Transportation Officials
NAU	Needs Assessment Unit
NBAP	National Biodiversity Action Plan
NCA	National Conservation Act
NCC	National Conservation Council
NEP	National Energy Policy Unit
NPV	Net Present Value
NRA	National Roads Authority
NT	National Trust
PAHI-TD	Planning, Agriculture, Housing, Infrastructure, Transport & Development
PHF	Peak Hour Factor
PS	Performance Standard
PV	Photovoltaic
PVB	Present Value of Benefits
RCIPS	Royal Cayman Islands Police Service
RCUT	Restricted Crossing U-Turn
RDI	Richards and Dumbleton International
ROW	Right-of-Way
RVE	Remington & Vernick Engineers
SFWMD	South Florida Water Management District
SO_2	Sulphur Dioxide
SOAEL	Significant Observable Adverse Effect Level
SWPPP	Stormwater Pollution Prevention Plan
TDM	Travel Demand Model
TMC	Turning Movement Count
TNM	Traffic Noise Model
ToR	Terms of Reference
UK	United Kingdom
UMAM	Uniform Mitigation Assessment Method
UNFCCC	United Nations Framework Convention on Climate Change
U.S.	United States
USD	United States Dollar
USDOT	United States Department of Transportation
VMT	Vehicle Miles Travelled
WAC	Water Authority Cayman
WebTAG	UK Transport Appraisal Guidance
WRA	Whitman, Requardt & Associates, LLP
yd^3	Cubic Yards

List of Appendices

1 Introduction

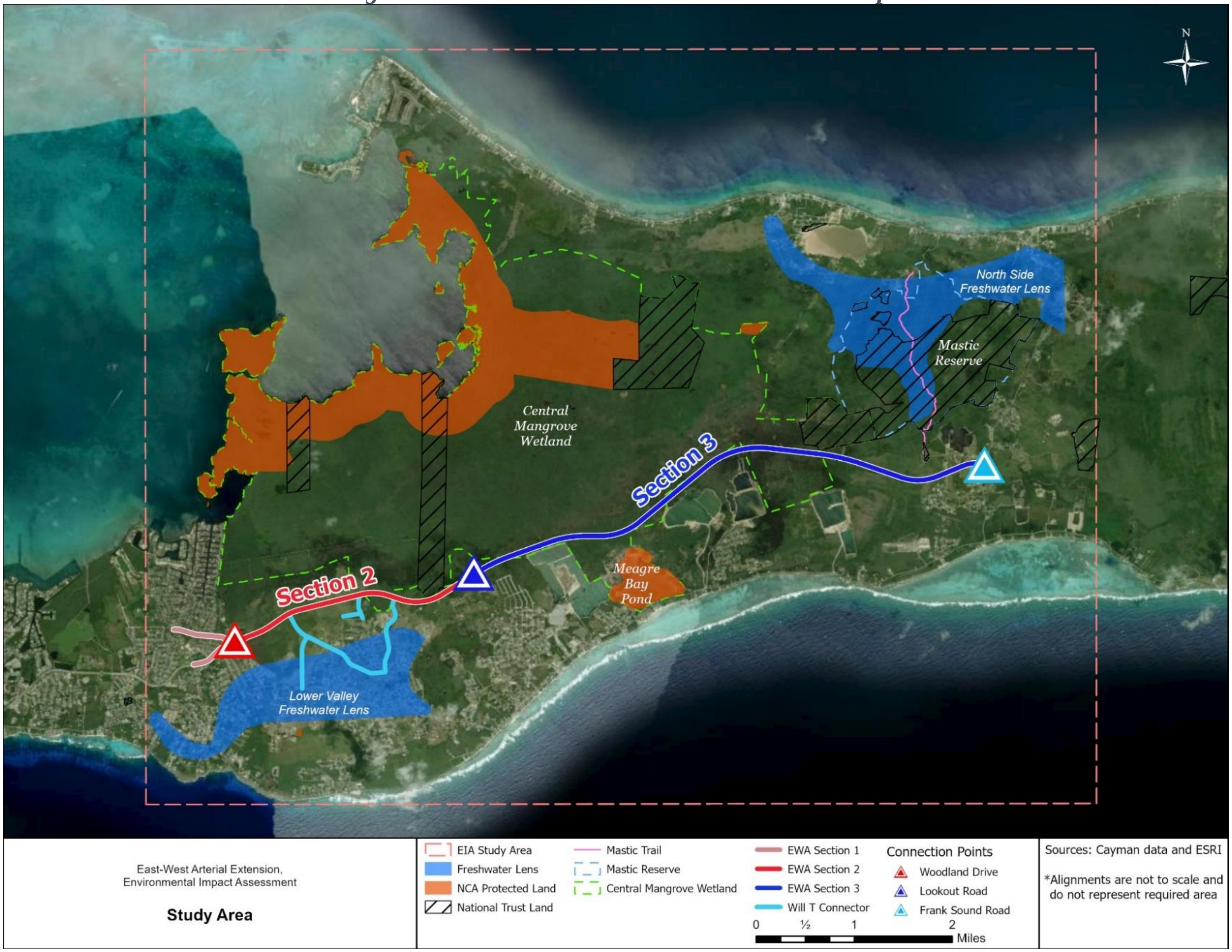
1.1 Overview of the Proposed Development

The proposed further East-West Arterial (EWA) Extension is a multimodal corridor that connects Section 1 of the EWA Extension from Woodland Drive in Savannah to Frank Sound Road in Breakers on Grand Cayman (**Figure 1-1**). The EWA Extension is proposed to improve traffic conditions between the eastern and western districts of Grand Cayman, bolster resiliency by adding a second travel route between districts, and to facilitate easier and more timely access to amenities in the western districts along with tourism destinations in the eastern districts. The objectives of the project are to:

- Create an alternative travel route to the existing two-lane coastal roadway.
- Improve resiliency and reliability of travel route between North Side/East End and George Town/West Bay.
- Support current and future traffic demand.
- Improve travel time between North Side/East End and George Town/West Bay.
- Improve safety for vehicular and multi-modal travel.
- Provide opportunity to safely accommodate and expand resilient, reliable public transportation.

This travel route is important for emergency services, enhancing evacuation capability, user delay, and travel time reliability for employment opportunities, equity, and overall quality of life, especially 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. Additional project needs are discussed in **Section 1.3: Project Need** and the key objectives are discussed in **Section 2.1: Project Objectives**.

Figure 1-1: EWA Extension General Location Map



1.2 Project Background

The EWA Extension comprises three sections. Section 1 extends between Hirst Road and Woodland Drive and is currently under construction. Section 2 would connect Woodland Drive to Lookout Road, and Section 3 would connect Lookout Road to Frank Sound Road. The project background, as documented in the Terms of Reference (ToR), is included below.

In May 2005, the proposed EWA Extension corridor **(Figure 1-2)** was initially planned and gazetted by the National Roads Authority (NRA) in the Cayman Islands Gazette, Extraordinary Supplement, Number 13/2005, in accordance with Section 25 (4) (a) of the Roads Law (2000 Revision), now Section 26 (4)(a) 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.

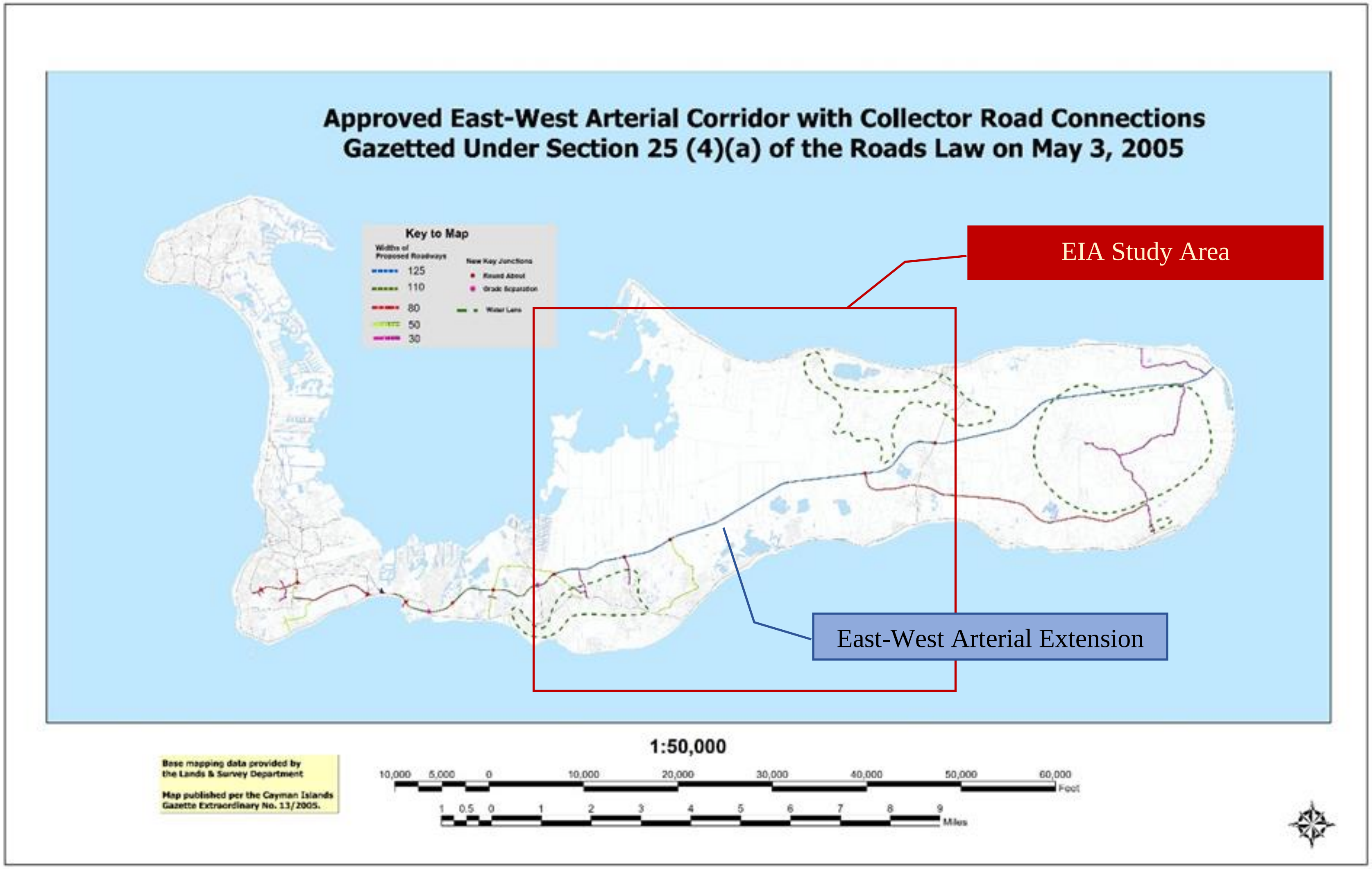
After an intervening period of deprioritisation, there was a renewed focus on the EWA Extension in 2016 and discussions regarding an Environmental Impact Assessment (EIA) for the proposed project were restarted. In accordance with the EIA Directive, the Department of Environment (DoE) issued a Screening Opinion on October 12, 2016, for the EWA Extension. At its Special General Meeting of October 26, 2016, the National Conservation Council (NCC) reviewed the Screening Opinion and took a decision to require an EIA of the proposed EWA road extension (Sections 1, 2, and 3). The NRA were informed of this requirement.

On September 24, 2019, the Ministry of Commerce, Planning, and Infrastructure (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 EWA Extension from Hirst Road to Lookout Gardens (Sections 1 and 2). At a meeting with NRA and Ministry officials on October 22, 2019, it was agreed that the section from Hirst Road to Woodland Drive (Section 1) 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 October 22, 2019, that an EIA would need to be conducted for the route from Woodland Drive to Lookout Gardens (Section 2).

This was endorsed by the NCC at its meeting on October 30, 2019, and an Environmental Assessment Board (EAB) was empanelled to guide the EIA. On November 19, 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 CPI and NRA) did not commence an EIA for this portion of the road at that time.

On October 9, 2021, the NRA requested a Scoping Opinion for the proposed EWA Extension from the Woodland Drive area to Frank Sound Road (Section 2 and Section 3). This Scoping Opinion was issued on the November 5, 2021, and outlines the likely significant effects of the EWA Extension project which will need to be assessed under the EIA framework.

Figure 1-2: 2005 Gazetted Corridor Section 26 (4)(a) Roads Law (2005)



On August 5, 2022, the Public Procurement Committee approved the selection of Whitman, Requardt & Associates, LLP (WRA) for the Professional Services to Perform an EIA for the EWA Extension service agreement. This agreement included two phases: the Terms of Reference (Phase 1) and the EIA (Phase 2). In August 2022 WRA was contracted to begin the Terms of Reference (Phase 1).

A Draft ToR, dated January 30, 2023, was then developed for the proposed EWA Extension. As prescribed by the EIA Directive, the Draft ToR was available on the DoE's website for a total of 21 consecutive days and advertised twice in the local press within the 10-day period immediately prior to the start of the 21-day review period. In addition, two public meetings were held during the review period to allow the public to review the ToR and engage with the EWA Extension project team regarding questions or concerns about the project. These two public meetings were held on Grand Cayman, with one meeting each on the eastern and western sides of the island including:

- Craddock Ebanks Civic Centre, 923 North Side Road, North Side, 6 pm to 9 pm on Tuesday, February 7, 2023
- Cayman Islands Baptist Church, 163 Pedro Castle Road, Savannah, from 6 pm to 9 pm on Thursday, February 9, 2023

The Final ToR was then prepared and approved on April 4, 2023. The public comments and responses from the draft ToR public involvement effort were included in the appendix. The Final ToR further refined the scope of the EIA established in the initial Scoping Opinion. The Final ToR also provided a defined protocol for assessing the project's potential impacts. In June 2023, WRA was contracted to complete the EIA (Phase 2) of the service agreement.

A visual timeline of the project background is represented in **Figure 1-3** below.

Figure 1-3: Project Background Timeline

2005

May: Proposed EWA Extension corridor gazetted

2016

October 12: DoE issued a Screening Opinion for EWA Extension (Hirst Road to Frank Sound Road)

October 26: NCC reviewed the Screening Opinion and decided to require an EIA for the EWA Extension

2019

September 24: Ministry of CPI proposed proceeding with construction for part of the EWA (Hirst Road to Lookout Gardens)

October 22: Agreement that Section 1 (Hirst Road to Woodland Drive) could be constructed without an EIA, Section 2 (Woodland Drive to Lookout Gardens) required an EIA

October 30: NCC endorses decision, empanels EAB to guide EIA

November 19: EAB issued Scoping Opinion for Section 2 (Woodland Drive to Lookout Gardens)

2021

October 9: NRA requested Scoping Opinion for Section 2 and 3 (Woodland Drive to Frank Sound Road)

November 5: Scoping Opinion issued

2022

August 5: Selection of WRA to perform a ToR and EIA for the EWA Extension

2023

January 30: Draft ToR developed for proposed EWA Extension

February 7 & 9: Draft ToR Public Meetings

April 4: Final ToR approved

June: WRA contracted to complete EIA

1.3 Project Need

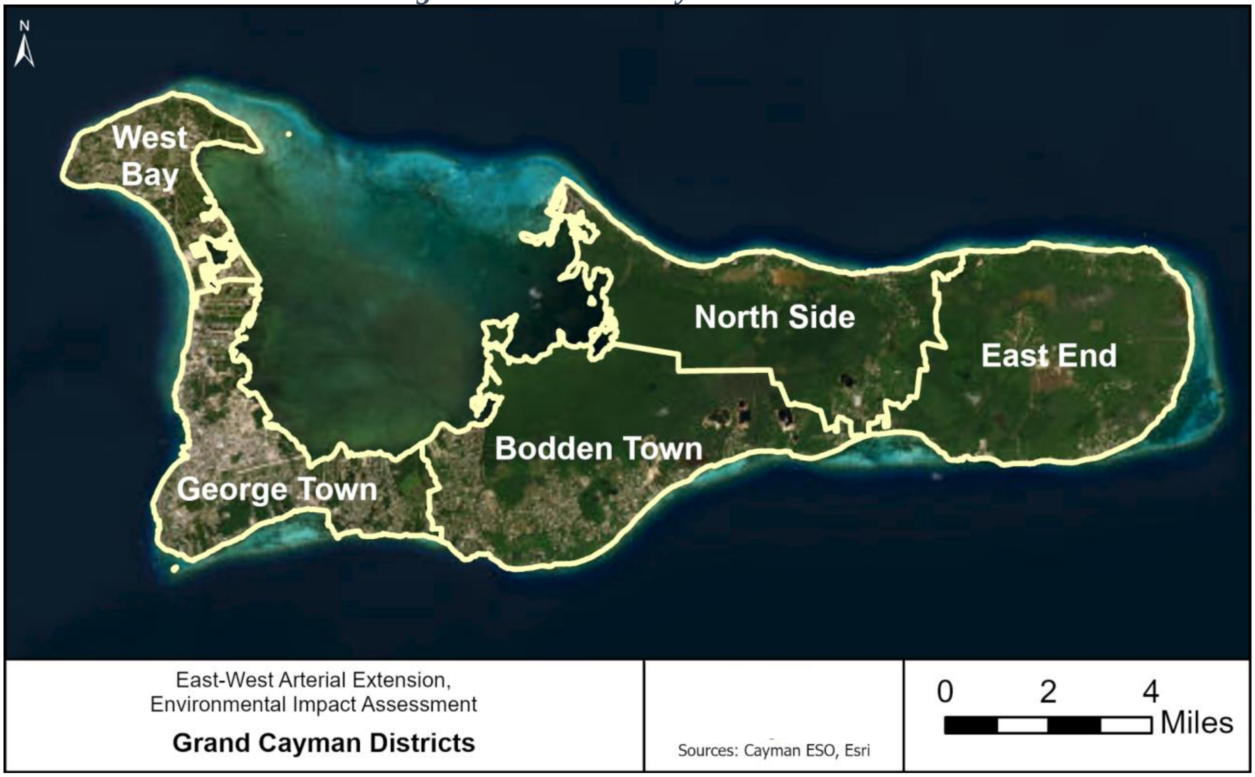
As noted in the ToR, currently a single coastal road, Bodden Town Road, provides access between the eastern and western sides of Grand Cayman. Made up of one lane in each direction, Bodden Town Road is vulnerable to traffic congestion, especially during peak travel hours when people from the eastern side of the island commute to access employment, education, and other services on the western side.

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. Existing coastal roads are especially vulnerable and without an alternative travel corridor, portions of Grand Cayman become isolated during major storm events, such as Hurricane Ivan. During extreme weather events, the coastal roadways become compromised and inaccessible, stranding East End residents from accessing goods and services mainly located on the west side of Grand Cayman. Throughout the world the practice of elevating roads has become a flood abatement measure; however, doing so typically requires much property, which can be a constraint when residential and commercial properties are directly adjacent to the roadway, as is the case with Bodden Town Road. Transportation resilience has been identified as a key element that is critical for the socio-economic stability and safety of the population. The EWA Extension would serve as a central and alternative route when low-lying coastal areas are compromised by storm surges.

The United Kingdom (UK) 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 potential effects; and **recovery**, which involves plans and courses of action to respond to and resolve negative effects of climate change. In developing the EWA Extension corridor, consideration was given to alternatives that are able to prepare, adapt, and recover from potential effects of climate change.

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 (**Figure 1-4**) to aid in easing the traffic congestion currently experienced on the coastal, two-lane Bodden Town Road.

Figure 1-4: Grand Cayman Districts



1.4 EIA Study Scope

In June 2022, the Cayman Islands Government (CIG) retained WRA, in association with acquired subconsultants (see **Section 1.5.2** below), to undertake the environmental and engineering studies for the EWA Extension EIA. The scope of the EIA is defined in the ToR dated April 4, 2023. This comprehensive document defines study protocols for each of the following considerations:

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

The overall scope of the environmental studies included the following key tasks:

- Definition of baseline site and environmental design conditions;
- Development and assessment of alternative project alignments;
- Identification and assessment of anticipated environmental impacts and socio-economic impacts related to project development;

- Identification and assessment of possible mitigation considerations to reduce negative impact;
- Preparation of an Environmental Statement (ES) summarizing the results of the EIA, including technical appendices for each EIA consideration listed above, as well as an Environmental Management Plan (EMP) for the project.

1.5 EIA Project Team

1.5.1 Project Sponsor

The NRA is the sponsor of the EWA Extension project. The NRA is the statutory authority that is responsible to administer, manage, control, develop and maintain the Islands' public roads and related facilities, such as signals, stormwater facilities, roadway lighting, roadway directional signage, etc. It performs the following: carry out, either through its employees or through independent contractors, the necessary routine periodic and emergency public road maintenance activities in accordance with the service level of maintenance established for each class or type of public road; collects information on the performance of the existing transportation system; forecasts future traffic demand; and identifies possible solutions to anticipated issues in system performance and deficiencies (NRA, 2024).

The NRA reports to the Ministry of Planning, Agriculture, Housing, Infrastructure, Transport & Development (PAHI-TD). The Ministry of PAHI-TD is responsible for a wide range of areas that concerns the planning, agriculture, housing, and infrastructure needs across the Islands. Customers of the Ministry are varied and include residents, visitors, as well as commercial, private and public sector entities, both international and on a local level. Activities take place on the three islands of Grand Cayman, Cayman Brac and Little Cayman.

1.5.2 Project Consultant Team

As noted in **Section 1.4** above, WRA was retained by the CIG to undertake the environmental and engineering studies for the EWA Extension EIA. An overview of the EIA consultant team is provided below:

- WRA oversees the EIA study and the ES document.
- Resource Environmental Solutions, LLC (RES) provides technical assistance with the terrestrial ecology study for the EIA.
- Stantec provides the GHG emissions evaluation for the EIA.
- EBP U.S., Inc. provides the Cost-Benefit Analysis (CBA) for the EIA.
- AMR Consulting Engineers provides geotechnical study for the EIA.
- Tower provides marketing and communications services for the EIA.

1.5.3 Project Third-Party Consultant

TYLin acts as a third-party reviewer for the NRA to ensure an impartial EIA process.

Technical studies and analyses were also requested by the NRA and performed by W.F. Baird & Associates Coastal Engineers, LTD (Baird) and Remington & Vernick Engineers (RVE) in support of this EIA and included rainfall analysis, hydrology and hydraulic analysis, water budget analysis for the Central Mangrove Wetland (CMW), and a coastal risk study.

1.5.4 Project Steering Committee

For the EWA EIA Project, the NRA, EAB, and other involved parties agreed to form a Steering Committee that met monthly to provide a consistent coordination exchange of study information; and to discuss and provide direction on key decision points. While such committees are not a typical part of the EIA process, the Steering Committee is a valuable component of the EIA process for the EWA. The Steering Committee is comprised of:

- NRA (project sponsor)
- EAB, consisting of DoE (chair), Department of Planning (member), and the Water Authority Cayman (member), Public Works Department (member)

Additional Steering Committee attendees include:

- WRA (primary EIA consultant)
- TYLin (third-party reviewer for the NRA)
- Ministry of PAHI-TD
- Ministry of Sustainability & Climate Resiliency

2 Project Objectives and Key Constraints

2.1 Project Objectives

The key objectives of the project, referred to as Critical Success Factors (CSFs), are the aspects of the project that are vital to its success. These are the main goals that the project is designed to accomplish. The CSFs were developed based on the identified purpose and need statements from the original Gazetting of the EWA Extension and from the elements identified in the ToR for the EWA Extension EIA (**Table 2-1**).

Table 2-1: Critical Success Factors (CSFs)

Criteria	Target
a. **Alternative Routes:** Create an alternative travel route to the existing two-lane Bodden Town Road	Provide for an alternative roadway facility to accommodate travel in the event of a roadway closure
b. **Existing Roadway Resiliency:** Improve resiliency of the existing roadway travel route between North Side/East End and George Town/West Bay.	Improve resiliency of the travel route to flooding from sea level rise, storm surge, wave overtopping, and rainfall
c. **Future Traffic Demand:** Support current and future traffic demand.	Provide travel lanes necessary to accommodate projected trips/vehicles Provide controlled access points to enter roadway facility
d. **Commuter Travel Times:** Improve travel time between North Side/East End and George Town/West Bay	Improve projected travel time between North Side/East End and George Town/West Bay
e. **Utilities:** Accommodate utility expansion (electricity, fibre, water, central sewerage system) *	Establish area adjacent to roadway to provide for utility needs
f. **Public Transit Access:** Provide opportunity to safely accommodate and expand public transportation *	Establish public transportation facilities Improve bus travel time reliability
g. **Tourist Travel Times:** Reduce tourism travel time between North Side/East End and George Town	Reduce travel times between Owen Roberts International Airport and the North Side Reduce travel time between Grand Cayman Cruise Port (George Town Cruise Port) and Bodden Town/North Side/East End
h. **Safety:** Improve safe vehicular travel by reducing roadway conflict points	Reduce the number of Cross Street Intersections along the primary east-west corridor Reduce the number of Driveway Access Points along the primary east-west corridor
i. **Pedestrian and Bicycle Access:** Provide opportunity for enhanced and safe pedestrian and bicycle travel	Establish dedicated pedestrian and bicycle facilities adjacent to vehicular travel lanes

**These criteria are to provide opportunities to accommodate these features. It is outside of ambit of the NRA to provide public transportation or utilities*

2.2 Project Constraints

2.2.1 Environmental Constraints – Natural

The Environmental Constraints – Natural are identified as the study area's sensitive environmental resources. The goal of the project is to develop an alternative that best meets the identified objectives while avoiding and minimising impacts to environmental constraints and to provide for mitigation considerations for unavoidable environmental impacts. Key environmental constraints related to the natural environment include, but are not limited to avoiding or minimising disturbance to:

- Areas of Ecologically Valuable Habitat
- National Trust (NT) -Owned Natural Properties
- Freshwater Lens
- Mastic Reserve
- Meagre Bay Pond
- Land or Areas protected under the 2013 National Conservation Act (NCA)
- Central Mangrove Wetland (CMW)

2.2.2 Environmental Constraints – Social

The Environmental Constraints – Social are identified as the study area's sensitive social resources. The goal of the project is to develop an alternative that best meets the identified objectives while avoiding and minimising impacts to social constraints. Key social constraints related to the social environment include, but are not limited to avoiding or minimising disturbance to:

- Built Property
- Historic (Built) NT-Owned Properties
- Historic Overlay Zones
- Mastic Trail
- Cultural Heritage Sites (Heritage Register and Cemeteries)
- Community/Neighbourhood Cohesion

2.2.3 Engineering Constraints

The Engineering Constraints include the elements necessary to construct the proposed project. The key goals of the engineering process are to design an alternative for a sound and resilient roadway that best meets the identified objectives for the project and that avoid and minimise disturbance to the natural and social environmental constraints identified above. Details regarding engineering design requirements can be found in **Section 6.6: Design Criteria and Methodology**. Key engineering elements include, but are not limited to:

- Provide for sound geometric design conditions
- Plan for areas necessary for construction

2.3 Policy Context

Compliance with appropriate standards and regulations is a key component of the EIA. This section identifies the legislative and policy framework applicable to the EIA process and the preparation of an ES as stated in the ToR. Relevant policy and legislative frameworks were utilised to establish the scope of studies identified in the ToR and to provide conformity with existing guidelines and standards. Further clarification of standards and regulations for specific disciplines can be found in the individual discipline chapters under Assessment Methodology.

2.3.1 International Finance Corporation Performance Standards on Environmental and Social Sustainability

The International Finance Corporation (IFC), a member of the World Bank Group, developed Performance Standards (PS) 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 utilises these standards where appropriate to properly assess the potential risks.

2.3.2 Cayman Islands Constitution Order 2009

The Cayman Islands Constitution Order of 2009 was developed to establish the powers and activities of the legislative, executive, and judicial branches of government, as well as the rights of 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.*

2.3.3 Public Management and Finance Act, 2013 and 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 Act, 2013 and 2020 Revision. This act delineates the differences between ‘core government’ authorities and ‘statutory authorities.’

2.3.4 National Roads Authority Act, 2004 and 2016 Revision

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

2.3.5 Roads Law, 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 necessary legal requirements for roadway development and implementation.

2.3.6 Environment Charter, 2001

In 2001, the governments of the Cayman Islands and UK 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.

2.3.7 National Conservation Act (NCA) of 2013

The 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 NCC was established in order to guide and oversee the implementation of the NCA.

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.

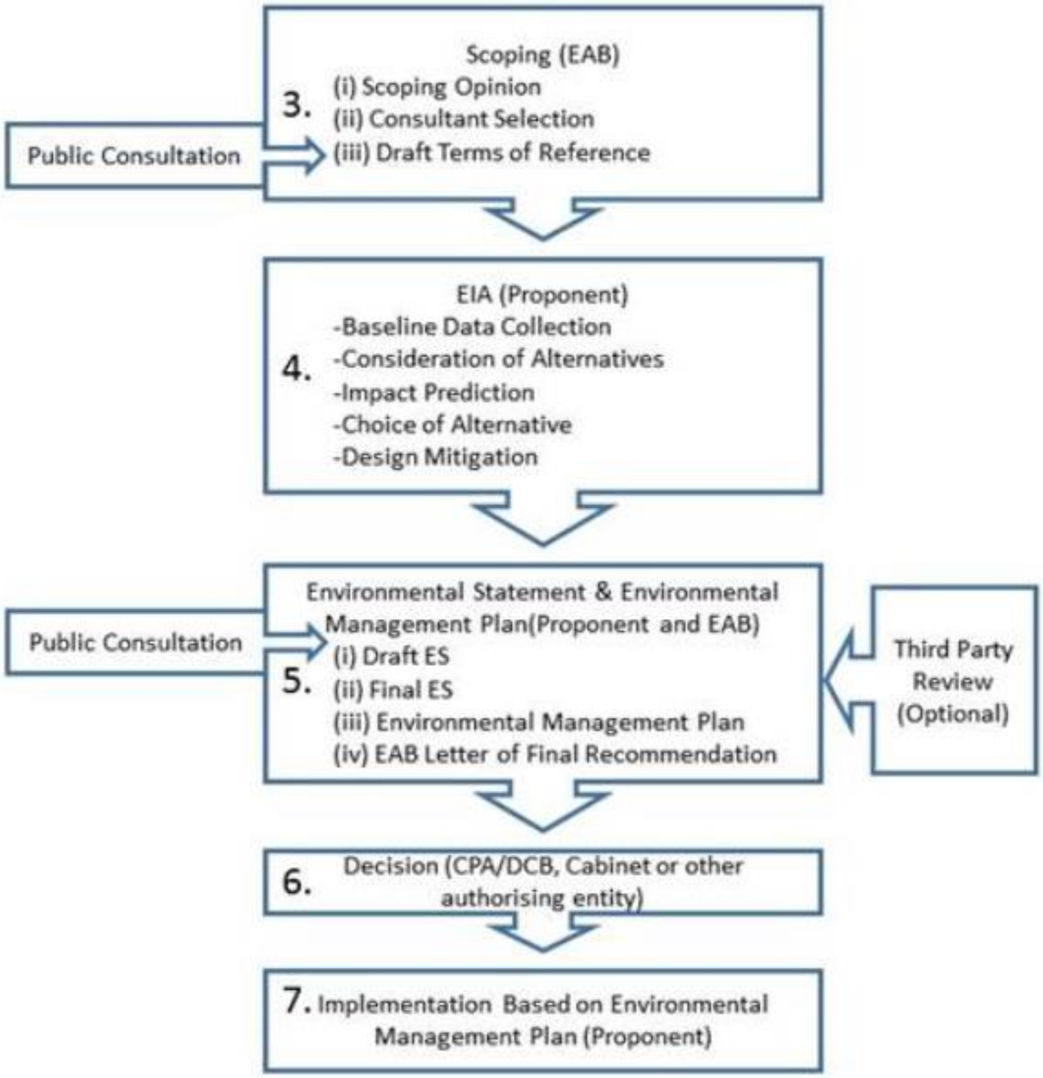
2.3.8 Directive for Environmental Impact Assessments, 2016

The development of an EIA with the results summarised in an ES is required under the Directive for Environmental Impact Assessments, governed under Section 43 of the NCA (NCC, 2016).

3 Environmental Impact Assessment Process

As presented in **Section 1.2**, it was determined that an EIA was required for Sections 2 and 3 of the EWA Extension. The items required for preparing the main components including the Scoping, EIA, ES, and the EMP are shown in **Figure 3-1** and are described in the following text.

Figure 3-1: Excerpted EIA Directive from NCC



3.1 Terms of Reference (ToR)

The ToR refined the scope of the EIA established in the Scoping Opinion, including considering comments received through public consultation. The ToR provided a protocol for assessing a project's potential to cause environmental, social, and economic harm. The ToR identified the applicable environmental laws and regulations, established the assessment methodologies, and guided the overall activities required for the environmental studies. The ToR also specified 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, potential cumulative impacts, and/or indirect effects. The ToR also provided an outline of possible suggestions to be considered on how the effects on these resources can be avoided, minimised and/or mitigated.

The ToR was approved for the EWA Extension on April 4, 2023, and can be viewed on both the NRA and NCC websites.

3.2 Environmental Impact Assessment (EIA)

As stated in the ToR, the EIA evaluates the potential effects of a project on the environment and ensures that the process for minimising or eliminating these effects are considered prior to development occurring. The assessment starts with the baseline data collection to establish and understand the existing environmental conditions against which the project will be assessed. An important aspect of the EIA is the consideration of alternatives, including a ‘‘No-Build’’ scenario, whereby the project is not constructed. The alternatives development process also involves the evaluation and assessment of reasonable Build alternatives and the potential effects of each alternative 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 considerations to be secured in an EMP.

According to the NCC EIA Directive, an EIA includes important “Impact Prediction” elements that are considered and discussed during the Assessment of Impacts. This characterization of impacts allows for the significance of the impact to be determined by a variety of factors. The Impact Prediction includes:

a) The sensitivity of the environmental resource;
b) The magnitude of change;
c) The likelihood of the impacts occurring;
d) The certainty with which impacts have been identified;
e) The comparison with the do nothing / future use of site; and
f) The significance of the impacts based on factors (a) – (d) above

3.3 Environmental Statement (ES)

As noted in the ToR, following the completion of the EIA, an ES is developed to summarise the results of the EIA. The ES is a guidance document for decision makers that provides them with the necessary information and the technical studies regarding the potential environmental effects of the project. The following information is included in the ES:

- Description of the development;
- Description of the alternatives studied and the reason for selecting the chosen alternative;
- Description of 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 other direct, indirect, or cumulative effects the project may have on the environment;
- Description of mitigation considerations to avoid or mitigate the environmental effects;
- Non-technical summary; and,
- Other difficulties (e.g., data gaps) that occurred during the EIA process.

3.4 Environmental Management Plan (EMP)

Using the results of the EIA, an EMP is developed. This EMP establishes the basis and plan for environmental monitoring and mitigation during project implementation.

Per the EIA Directive, the EMP should clearly state:

- Institutional arrangements for carrying out the work parameters to be monitored;
- Methods and best management practices to be employed;
- Standards or guidelines to be used and thresholds to be adhered to;
- Schedule and duration of monitoring (including details of initiation of action necessary to limit adverse impacts evident from monitoring);
- Format and frequency of reporting of results; and
- Actions to be taken, including stoppage of works, mediation of impacts and revocation of permits, for non-compliance with any aspect of the EMP.

The EWA Extension is at the conceptual design stage, and therefore an Initial iteration of the EMP has been produced. Future iterations and amendments to this EMP (outside of the EIA) are to be made by the NRA project management in consultation with the Cayman Islands' DoE, as a representative of the NCC. Future iterations and amendments are anticipated at the conclusion of the detailed design phase, and prior to each of the construction phases (estimated to be in 2026, 2036, 2046, 2060), or as needed based on new legal requirements or additional information.

3.5 Public Consultation and Stakeholder Engagement

3.5.1 Public Consultation Requirements

As noted in the ToR, due to the nature, magnitude and complexities of this EWA project and its potential impact on the residents of Grand Cayman, public consultation is imperative in project development. The NCA's EIA Directive establishes two requirements for public involvement during the development of an EIA.

The first requirement is during development of the draft ToR. This Directive states that 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 comments received have been appended to the ToR and ES respectively.

3.5.1.1 Public Consultation for the Draft ToR

For the EWA Extension project two public meetings were held to give the public an opportunity to review the Draft ToR and provide comments:

- Craddock Ebanks Civic Centre, 923 North Side Road, North Side, 6 pm to 9 pm on Tuesday, February 7, 2023
- Cayman Islands Baptist Church, 163 Pedro Castle Road, Savannah, from 6 pm to 9 pm on Thursday, February 9, 2023

Printed copies of the Draft ToR were available at the following locations:

- NRA Office – 370 North Sound Road, Grand Cayman;
- North Side Public Library – 891 North Side Road, North Side;
- Savannah Post Office – 1687 Shamrock Road, Savannah;
- Vernon L. Jackson Public Library and Learning Centre – 69 Bodden Town Road, Bodden Town; and
- East End Public Library – 2739 Sea View Road, East End

3.5.1.2 Public Consultation for the Draft ES

As required by the EIA Directive, the public consultation period for the Draft ES was open for 21 days, from January 13 through February 3, 2025. Notice of the public consultation period was published in the Cayman Compass on two separate occasions (January 3 and January 10, 2025). The Draft ES and the NTS were made available on the DoE website and the NRA website. Social media posts alerting the public to the opening, timing, and closing of the consultation period, the locations of the documents and meetings, and how to leave a comment, were posted on the NRA's Facebook and Instagram.

Printed copies of the Draft ES and NTS were available for viewing at:

- NRA Office – 370 North Sound Road
- DoE Office – 580 North Sound Road

Printed copies of the NTS were available for viewing at:

- North Side Post Office – 896 North Side Road
- Bodden Town Post Office – 189 Bodden Town Road
- Savannah Post Office – 1687 Shamrock Road
- Vernon L. Jackson Public Library and Learning Centre – 69 Bodden Town Road
- East End Public Library – 2739 Sea View Road
- George Town Public Library – 68 Edward Street

For the EWA Extension Draft ES, public meetings were held during the review period to allow the public to comment on the Draft ES and engage with the EWA Extension project team regarding questions or concerns they have about the project. Each meeting began with an open house that included informational display boards where attendees could interact with members of the project team, including the NRA, and the EAB. The open house was followed by a presentation by the project team and question and answer session. Questions were able to be asked in person as well as using the Slido application from both virtual and in-person attendees. The meetings were held on the following dates and at the following locations:

- Craddock Ebanks Civic Centre, 923 North Side Road, North Side, 6 pm to 9 pm on Tuesday, January 21, 2025, and livestreamed on NRA's Facebook
- Church of God Chapels Hurricane Shelter, Shamrock Road, Bodden Town, 6 pm to 9 pm on Thursday, January 23, 2025, and livestreamed on NRA's Facebook

The review and comment period for the Draft ES was instituted to collect questions, comments, and thoughts from the community on the studies completed for the EWA Extension Project. Comments that were received during the public comment period were carefully and thoroughly reviewed, recorded, and responded to in **Appendix N – Public Comment Responses**.

The main concerns raised by the public during the consultation period that resulted in updates to the ES are as follows:

- The estimated cost of the Proposed Project
- Providing additional, lower-resiliency design options

These comments were addressed by additional design options being evaluated and costed within **Chapter 6: Proposed Project – Engineering Features** and **Chapter 16: Cost-Benefit Analysis**.

3.5.2 Public Engagement

Additional public engagement occurred while the EIA was being completed. To communicate information about the EIA with the public, the NRA created a public-facing website which can be found at http://youreia.caymanroads.com. This website includes information about the Proposed Project, the areas of study, the project team, and frequently asked questions. The website was periodically updated with additional content in the form of Monthly Spotlights, which went in-depth into some study areas and detailed different parts of the EIA process.

Information was also made available on the NRA's Facebook (http://www.facebook.com/nraroads) and Instagram (https://www.instagram.com/national_roads_authority/) social media accounts. These accounts were updated bi-weekly with information about the process and links to important updates on the website, serving as a major way to drive traffic to the website.

The purpose of this communication strategy was to provide understandable and accurate education about the EIA process. The website and social media channels were also used to promote the public consultation period for the Draft ES.

3.5.3 Stakeholder Engagement

3.5.3.1 Land Use Charrette

On July 25, 2023, a Land Use Planning Charrette took place with the purpose of identifying different land use scenarios that may occur on Grand Cayman in future year 2074. The scenarios included both geographically based and intensity-based components: such as how many people will be there and where will they be on the island. The government ministries and departments that were in attendance included:

- NRA
- DoE
- EAB
- Department of Planning
- Ministry of Planning, Agriculture, Housing, and Infrastructure
- Ministry of Sustainability & Climate Resiliency
- Water Authority Cayman (WAC)

Additional information regarding the Land Use Charrette can be found in **Appendix C - Land Use Planning Charrette Summary Memorandum** and **Chapter 7: Transportation and Mobility**.

3.5.3.2 Data Requests

In July of 2023, a number of technical data requests were sent to applicable government ministries and departments including:

- Department of Planning
- DoE
- Economics and Statistics Office (ESO)
- Land and Survey Office
- Ministry of Education
- NT
- NRA
- Public Transport Unit
- WAC

The data collected from these groups along with information collected during field efforts provided a baseline of information for the EIA studies.

3.5.3.3 Meetings

Monthly status and coordination meetings occurred with the project EAB throughout the EIA process. Additional topic specific meetings also occurred with the project EAB and applicable agencies throughout the studies process.

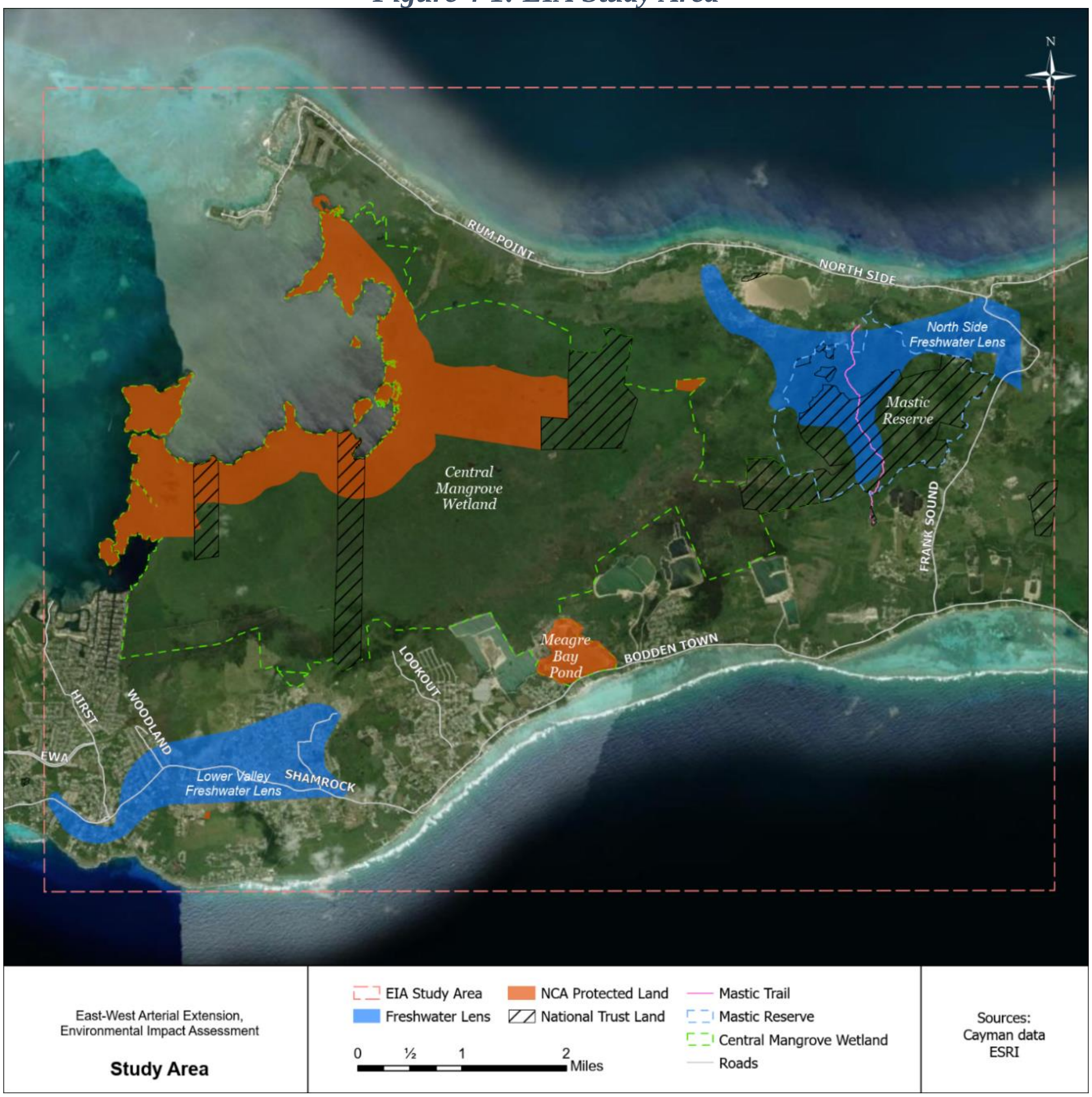
4 Project Study Area and Existing Conditions

4.1 Project Study Area

As established within the ToR, the 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 4-1)**. This area includes the corridor initially gazetted in 2005 for the EWA Extension. The study area was established to allow for the identification of a range of roadway and multimodal alternatives.

For specific evaluations (e.g., traffic and socio-economics), an island-based study area was utilised and is discussed within those chapters of the ES.

Figure 4-1: EIA Study Area



4.2 Geography and Natural Environmental

The Cayman Islands are relatively small, flat, and low-lying. The total area of the three islands is just under 100 square miles (mi^2) (259 square kilometres [km^2]). Islands tend to have high rates of endemic species, contributing to global biodiversity (Veron et al., 2019). Numerous endemic species call the Cayman Islands home, and they depend on the small, interconnected natural systems to sustain their populations.

Grand Cayman houses coastal, wetland, and upland ecosystems, which play an important role in providing ecosystem services and supporting native wildlife. Adjacent to the relatively untouched natural areas on Grand Cayman are varying degrees of human development, from farmland to urbanization. Both the natural and built environments have cultural and social value to Caymanians, whether that be the unique architecture found along Bodden Town Road, the public beaches, or the Mastic Trail. The complex interrelation between features and the social and natural environment will be further discussed throughout the ES. This section focuses on the geography and natural environmental features which lead to the development of the key natural environment constraints (**Section 2.2.1**). As depicted in **Figure 4-1**, the EWA EIA study area encompasses several protected natural areas and nature preserves on Grand Cayman.

Mangroves comprise approximately 30 mi^2 (78 km^2) or 36% of Grand Cayman's total land area. The CMW is a fundamental component of the natural ecosystem of Grand Cayman; this 8,655 acre (ac) (3,503 hectare [ha]) ecosystem is part of a large-scale, water flow system which filters and conditions the surface water and shallow ground water which flows into the North Sound while providing a constant flow of nutrients, which form the base of a complex food chain for both terrestrial and marine wildlife.

This system is also an integral part of the hydrological cycle on Grand Cayman, providing evapotranspiration and rainfall generation. Mangroves are essential to Grand Cayman's climate resiliency; they are capable of reducing the impacts of storm surges and flooding from hurricanes, filtering out nutrients, and acting as natural carbon sequesters, removing and storing carbon dioxide (CO_2) from the atmosphere (Alongi, 2012). The natural flow of the CMW also depends upon Grand Cayman's freshwater lenses: the Lower Valley freshwater lens, the North Side freshwater lens, the East End freshwater lens, and the South Sound freshwater lens. These lenses are an existing water supply source for potable water for a localized population, support agriculture and horticulture, including farming and residences with fruit trees and other crops, and the presence of specific naturally occurring vegetation.

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 CMW, with each providing different ecological benefits to the ecosystem. These mangroves are 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). The Grand Cayman Parrot, a subspecies of the Cuban Parrot endemic to the Cayman Islands and the Cayman National Bird also relies on mangroves for nesting and foraging habitat.

Located east of Bodden Town is the approximately 195 ac (79 ha) protected area of the Meagre Bay Pond, which is a pond surrounded by a protected 300 feet (ft) (91.4 metre [m]) mangrove buffer. Meagre Bay Pond has recorded over 104 different species of migratory birds that stop and eat fish that are stranded in Meagre Bay Pond between 2010 and 2017 (www.eBird.org). 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 NCA of 2013, 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.

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 ac (59 ha) of land to the NT for the purpose of protection and conservation of the old-growth forest and has since grown to 834 ac (338 ha).

Like the CMW, 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).

4.3 Social Environmental

Five districts make up Grand Cayman: West Bay, George Town, Bodden Town, North Side, and East End (**Figure 1-4**). With Owen Roberts International Airport and the George Town 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. Farther east, Bodden Town, North Side, and East End are primarily residential with some minor retail and community facilities interspersed along the existing roadways. Additionally, these three districts house the majority of Grand Cayman's remaining natural spaces. Bodden Town is currently the fastest growing district, almost tripling in population size since the turn of the 21st century, while North Side and East End have smaller populations.

According to the Economic and Statistics Office's 2022 Compendium of Statistics (CoS), the Cayman Islands had a population of 71,105 at the end of 2021 and 81,546 at the end of 2022, with an average household size of 2.4 persons. The populations and average household sizes of the five Grand Cayman districts were as follows at the end of 2022:

- George Town – 40,957 people, average household size of 2.3 persons
- West Bay – 16,943 people, average household size of 2.4 persons
- Bodden Town – 16,957 people, average household size of 2.7 persons
- North Side – 2,110 people, average household size of 2.7 persons
- East End – 2,274 people, average household size of 2.6 persons

Population distribution favours working-age individuals, with those between ages 30 and 49 representing a significant portion of the population. The 2022 labour force included 57,582 people, with 56,355 of those people reported as being employed. The industries employing the most people were construction (8,827 people), wholesale and retail (7,201 people), and professional, scientific and technical activities (5,200 people).

The EIA study area (**Figure 4-1**) encompasses both Bodden Town and North Side. Most existing development within the EIA study area is concentrated along the southern coast (Bodden Town Road) with additional developed areas along the northern coast (North Side Road) and north-south connector roadway (Frank Sound Road). Bodden Town is the former capital of the Cayman Islands and contains a number of historic resources, including NT owned properties (such as Guard House Park and the Mission House). Several unprotected historical resources (such as cemeteries and cottages with wattle and daub or shiplap walls) are listed under the NT heritage register and are encompassed by a historic overlay zone recognized by the Cayman Islands Department of Planning.

As discussed in **Section 4.2**, both the natural and built environments have cultural and social value to Caymanians. Outside of the developed areas are a number of natural resources with societal significance that contribute to the cultural identity of the Cayman Islands. Many plant and animal species that reside in the protected ecosystems described in the previous subsection are inherent to this cultural identity, such as the Silver Thatch Palm (the National Tree), the Cayman Parrot (the National Bird), the Banana Orchid (the National Flower), Ironwood, Tea Banker, and Cedar.

Along with its ecological importance, the CMW contains cultural and social significance for the inhabitants of the Cayman Islands. Portions of the CMW receive legal protection: the mangrove buffer zone around North Sound and Little Sound, as well as other land parcels are protected under the NCA. The NT has purchased several land parcels of the CMW to maintain them for conservation and environmental protection. Local groups, such as the Cayman Islands Mangrove Rangers and Sustainable Cayman, also prioritize the CMW in their efforts.

The Mastic Trail gives visitors a look into some of the oldest habitat on Grand Cayman by taking hikers through the centre of the Mastic Reserve. From the trail, people can observe culturally important species like the Banana Orchid, and guided tours of the trail can be booked via the NT. Local history enriches the story: in the early days of human settlement on the Cayman Islands, a passage through the Mastic habitat was used as a way to traverse the large mangrove system central to Grand Cayman. In 1995, the passageway was re-established as an official trail, the Mastic Trail, and dedicated to the public, allowing users to experience the natural, undisturbed areas of Grand Cayman (NT, 2022). The trail is a popular hiking destination for residents and visitors to the Cayman Islands and has received write-ups in travel journals including Frommer's and U.S. News Travel. The Mastic trail received an estimated 1,772 visitors in 2015 (Childs et al., 2015).

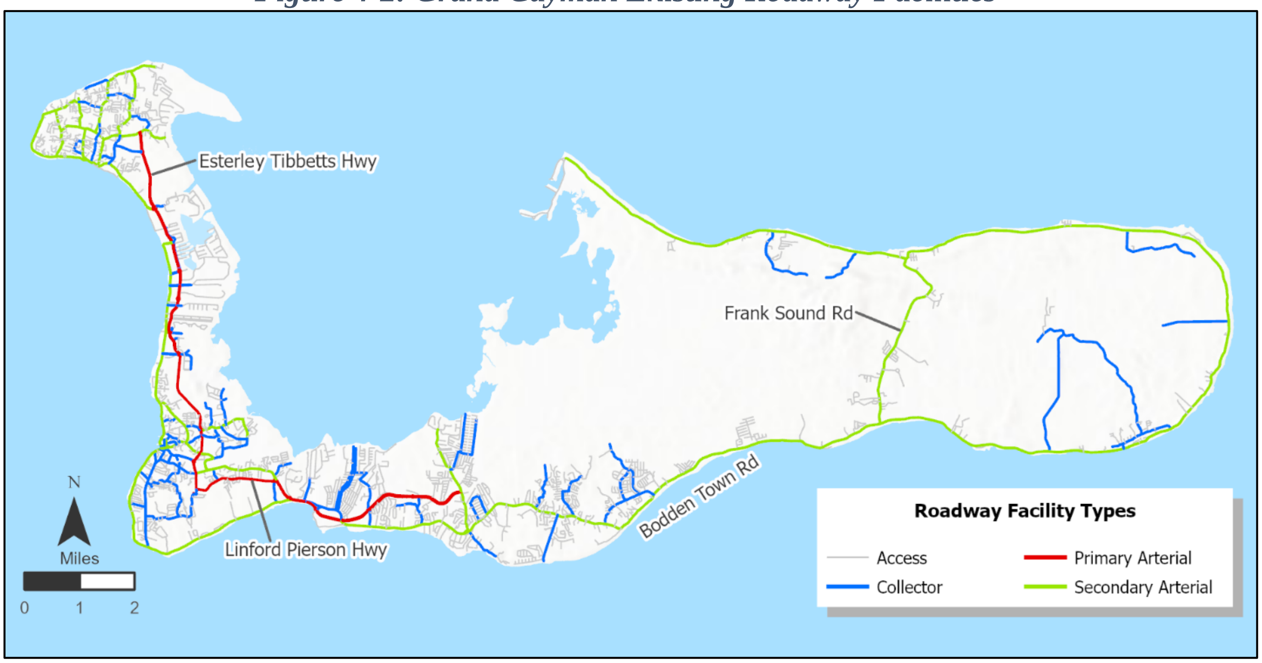
4.4 Existing Roadway Facilities

As noted in the ToR, 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 (**Figure 4-2**). In West Bay, Esterley Tibbetts Highway (ETH) is a four-lane divided highway connecting southeast West Bay to northern George Town. Within George Town, Linford Pierson Highway (LPH), 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, LPH 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 currently the only interior roadway which connects Bodden Town Road with North Side Road.

Figure 4-2: Grand Cayman Existing Roadway Facilities



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 (further discussed in **Section 4.5**).

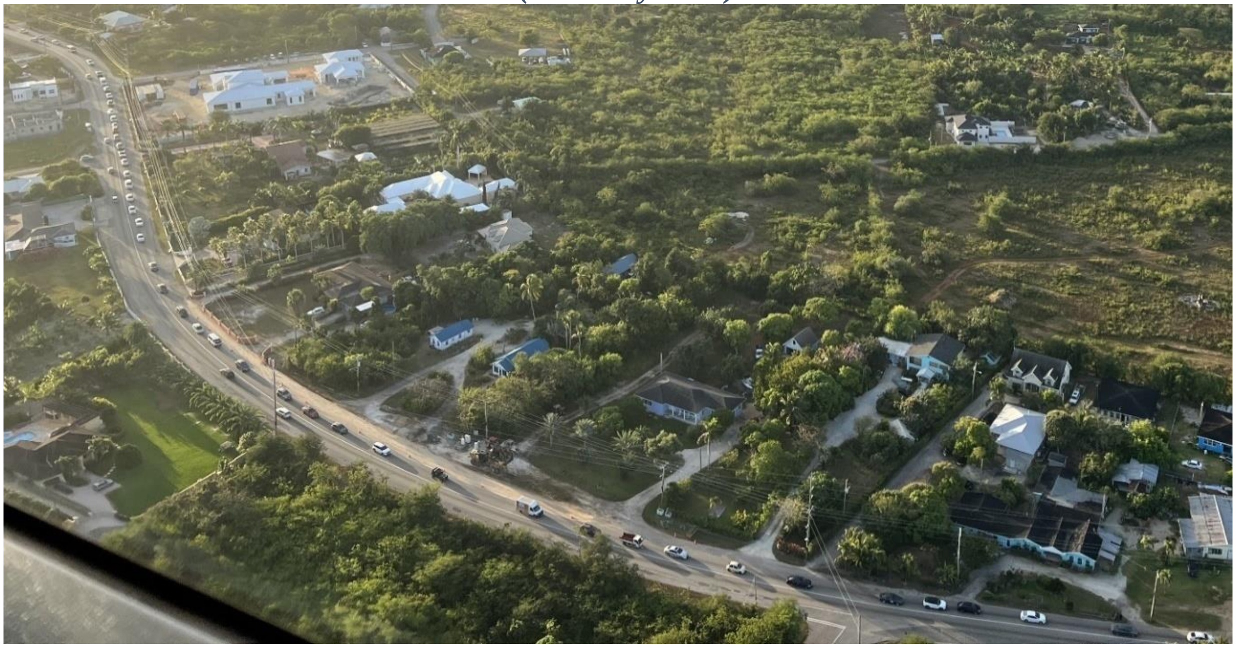
Existing coastal roads are also especially vulnerable to the effects of climate change, sea-level rise, and tropical storms. During extreme weather events such as Hurricane Ivan, the lone coastal route, Bodden Town Road, easily becomes compromised and inaccessible. Roadway closures can occur due to natural events such as flooding and fallen debris, as well as from manmade incidents such as traffic accidents or roadway maintenance. The absence of an alternative route to carry traffic during such events leaves thousands of East End and North Side residents unable to travel east-west, essentially stranding them on one end of the island for several hours or up to several days depending on the cause of the closure. Although some medical services are offered in the eastern districts at the Health City Cayman Islands Hospital (also known as Shetty Hospital) in East End and at health clinics in each district, critical emergency services like the Health Services Authority (HSA) Hospital in George Town may become inaccessible to eastern districts during storm or flood events. It is worth noting that the HSA Hospital in George Town is the only authorized provider of 24-hour Accident and Emergency Services in Grand Cayman. Eastern residents may also be cut off from jobs, schools, and other resources located in western districts.

Additional details regarding the existing roadway facilities and applicability to the Proposed Project are included in **Chapter 6: Proposed Project – Engineering Features**.

4.5 Existing Traffic Operations

Under existing traffic conditions, Grand Cayman residents of North Side and East End endure extended commutes, sometimes lasting hours due to congestion on the existing coastal roadway. **Figure 4-3** shows existing morning peak hour queuing along westbound Shamrock Road near Will T Road that was observed in February 2023, illustrating the congestion issues prevalent along the coastal road. As the population of Grand Cayman continues to grow, this worsening congestion highlights the need for improved roadway infrastructure.

Figure 4-3: AM Westbound Congestion, Shamrock Road Looking East Near Will T Road (February 2023)



To better understand Grand Cayman's traffic operations from a system-wide, holistic perspective, the NRA developed the Grand Cayman Travel Demand Model (GCM) in 2019 to evaluate current traffic congestion issues, as well as to estimate how future traffic conditions may be impacted by continued population growth, changes in land use, and the development of transportation improvements such as the EWA Extension. The GCM was created to encompass the diverse spectrum of travel patterns observed on Grand Cayman, including that of residents on the island, short-term visitors such as cruise passengers, and long-term visitors who arrive via the airport by drawing upon a comprehensive dataset including census socioeconomic data, cruise passenger surveys, long-term visitor surveys, and traffic counts collected across the island. The original baseline model development was documented and reviewed by outside experts as part of an independent modelling task. For this EWA Extension EIA, the GCM was updated to incorporate more recent data, with particular focus on the roadways of the eastern districts of Bodden Town, North Side, and East End. The GCM was used as the primary tool to evaluate the impacts of potential improvement alternatives on future traffic conditions; and to produce estimates of multimodal travel including cars, trucks, walking, biking, and transit to capture potential impacts for all users. The traffic modelling completed for this EWA Extension EIA is discussed in more detail within its subsequent chapter.

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.

Additional details regarding the existing traffic operations and applicability to the Proposed Project are included in **Chapter 7: Transportation and Mobility**.

5 Assessment of Alternatives Analysis

5.1 Alternatives Analysis Process

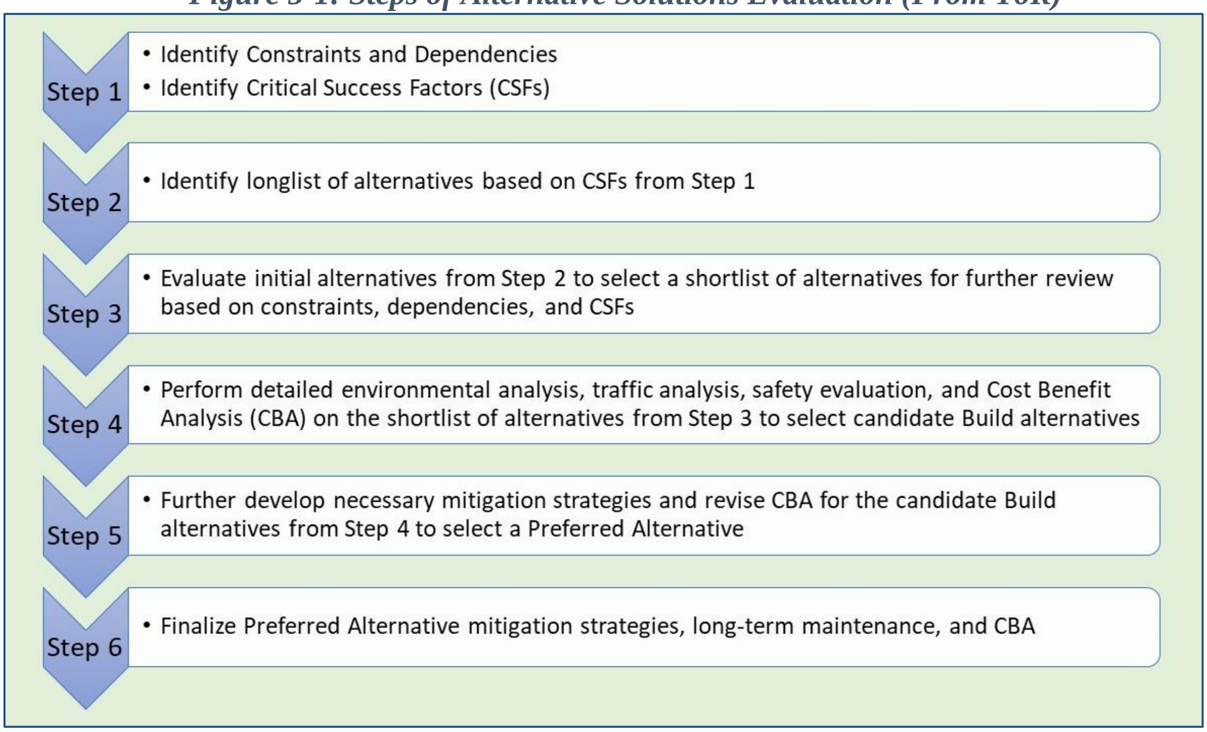
As noted in the ToR, the focus of the alternatives analysis is to ensure that the design of the project provides the best possible outcome for meeting the existing and projected travel needs while effectively preserving the environment as well as accommodating the needs of the surrounding communities.

With the focus on improving connectivity, safety, and emergency evacuation capability, an initial range of alternatives is identified, which includes a No-Build scenario, alternatives that utilise the existing roadway network and alternatives on new location. Additionally, the proposed alternative corridors would have the ability to include other modes of travel including passenger transit as well as pedestrian and multimodal facilities.

Each of the initial Build alternatives is designed to the concept level in an effort to meet the 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, are identified. These alternatives are then analysed using a transportation and environmental screening process to determine the viability of each alternative and determine which one(s) should move forward. The screening process is based upon the established CSFs, as well as constraints and dependencies (e.g., construction considerations and the evaluation of mitigation opportunities for unavoidable impacts).

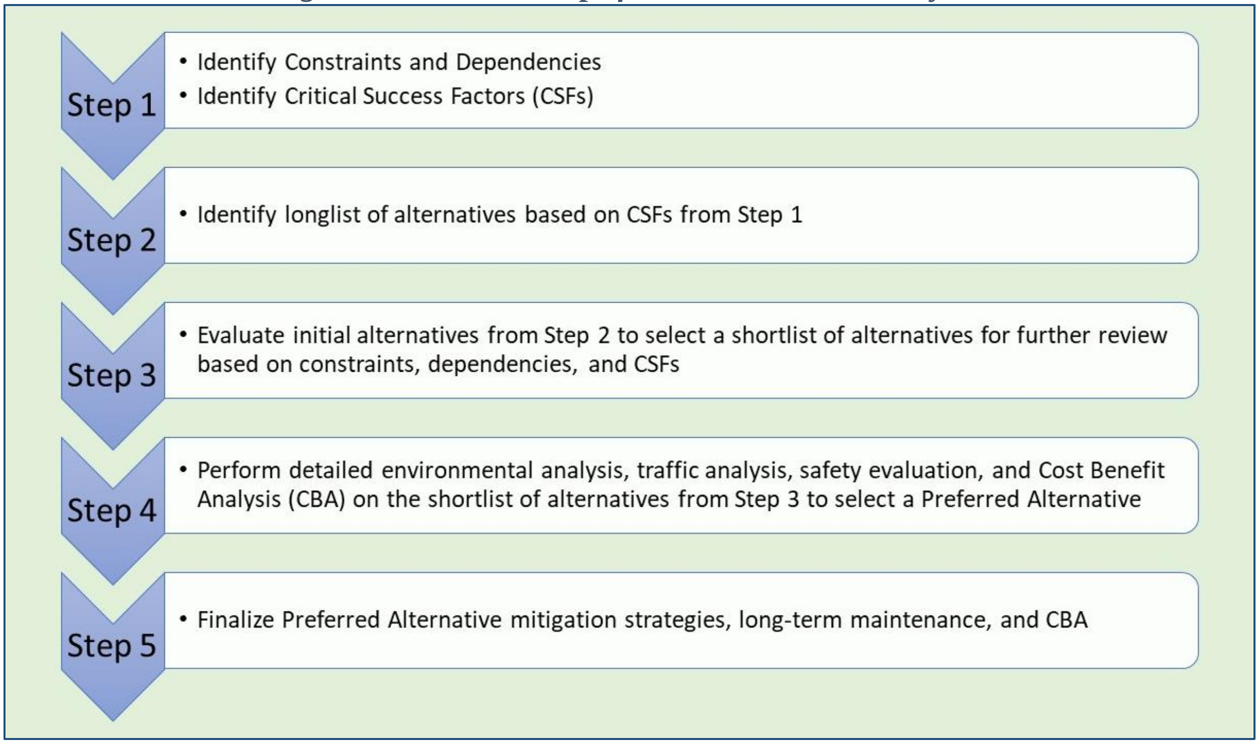
Figure 5-1 depicts the Steps identified for the Alternative Solutions Evaluation, as presented in Section 3.2 of the ToR.

Figure 5-1: Steps of Alternative Solutions Evaluation (From ToR)



Based on discussion with the EAB and NRA, it was determined that this alternative analysis would be slightly modified to more streamline the study and alternatives development process. **Figure 5-2** depicts the revised Steps for the Alternatives Analysis that was prepared for this project. The primary modification to this process was the deletion of Step 5, which indicates the evaluation of Candidate Build alternatives. Based on the development of alternatives, a higher level of detail has been included within the studies performed in Step 4 in order to facilitate the recommendation of the Preferred Alternative from this step (Step 4). The following sections describe the alternatives and the analyses conducted for Step 4, the impacts anticipated from each alternative and the identification of a Preferred Alternative.

Figure 5-2: Revised Steps for the Alternative Analysis



Step 1: The constraints and dependencies, as well as the CSFs, were clearly identified.

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

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

Step 4: Additional analysis was conducted on the shortlist of alternatives in order to select a Preferred Alternative. This included the following analyses:

- A comparison matrix of alternatives and the No-Build was developed. The comparison matrix included:

    - 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 was conducted from a multimodal perspective of project mobility benefits and impacts for each of the alternatives and for Years 2026, 2036, 2046, and 2074. These future year traffic projections were developed and based upon growth rates from the census along with known approved and planned land development, which provided a future land use condition. The results of this analysis fed back into the roadway design to determine the solution(s) that met the CSFs, which included refinements such as number of through lanes and intersection configurations.
- A multimodal qualitative or quantitative safety evaluation was also conducted to determine potential safety benefits and/or implications for each of the alternatives.
- A CBA was performed to provide a monetary measure of the relative economic desirability of project alternatives, weighed against non-monetised effects, and impacts of the project.

Step 5: Based upon the evaluations in Step 4, a Preferred Alternative was selected and further evaluated through development of mitigation strategies, long-term maintenance, and an updated CBA.

5.2 Longlist of Alternatives

The Longlist of Alternatives included five Build alternatives, depicted in **Figure 5-3**, and the No-Build. The five Build alternatives were described in the Longlist Alternatives Evaluation as follows:

- **Alternative B1 Assumptions:**
    - Build in Gazetted Corridor for Section 2 and Section 3
    - Includes Will T Connector
    - Includes bridge and/or culvert structures for hydrologic connectivity
- **Alternative B2 Assumptions:**
    - Build in Gazetted Corridor for Section 2
    - Locates new roadway closer to Meagre Bay Pond
    - Includes Will T Connector
    - Includes bridge and/or culvert structures for hydrologic connectivity

- **Alternative B3 Assumptions:**
  - Build in Gazetted Corridor for Section 2 and Section 3
  - Eliminates northern spur at Frank Sound Road connection
  - Includes Will T Connector
  - Includes bridge and/or culvert structures for hydrologic connectivity
- **Alternative B4 Assumptions:**
  - Build in Gazetted Corridor for Section 2
  - Includes Will T Connector
  - Improvements to:
    - Lookout Road
    - Bodden Town Bypass east of Lookout Road
    - Bodden Town Road between Bodden Town Bypass and Frank Sound Road
  - Improvements would include widening (i.e., additional lane(s) of roadway capacity), elevating the roadway, and adding pedestrian/bicycle facilities.
  - Includes bridge and/or culvert structures for hydrologic connectivity
- **Alternative C1 Assumptions:**
  - On Alignment (existing roadway network) Alternative
  - Improvements to:
    - Bodden Town Road between Frank Sound Road and Shamrock Road
    - Shamrock Road between Bodden Town Road and Hirst Road
    - Hirst Road between Shamrock Road and the EWA
  - Improvements would include widening (i.e., additional lane(s) of roadway capacity), elevating the roadway, and adding pedestrian/bicycle facilities.

The Longlist Alternatives Evaluation is included in **Appendix A - Longlist [Alternatives] Evaluation**. This Longlist Alternatives Evaluation encompassed Step 1, Step 2, and Step 3 of the Alternatives Analysis Process discussed in **Section 5.1**. Five Build alternatives (B1, B2, B3, B4, and C1), depicted in **Figure 5-3** below, were evaluated as part of the Longlist Alternatives Evaluation along with the No-Build scenario.

The Longlist Alternatives Evaluation ranked each of the Build alternatives on a 1-to-5 scale for the CSFs and key constraints listed in **Section 2** above. **Table 5-1** below shows a summary of the rankings where a high score correlates to meeting the CSFs and avoiding key constraints and a low score correlates to not meeting CSFs and impacting key constraints.

Figure 5-3: Longlist of Alternatives

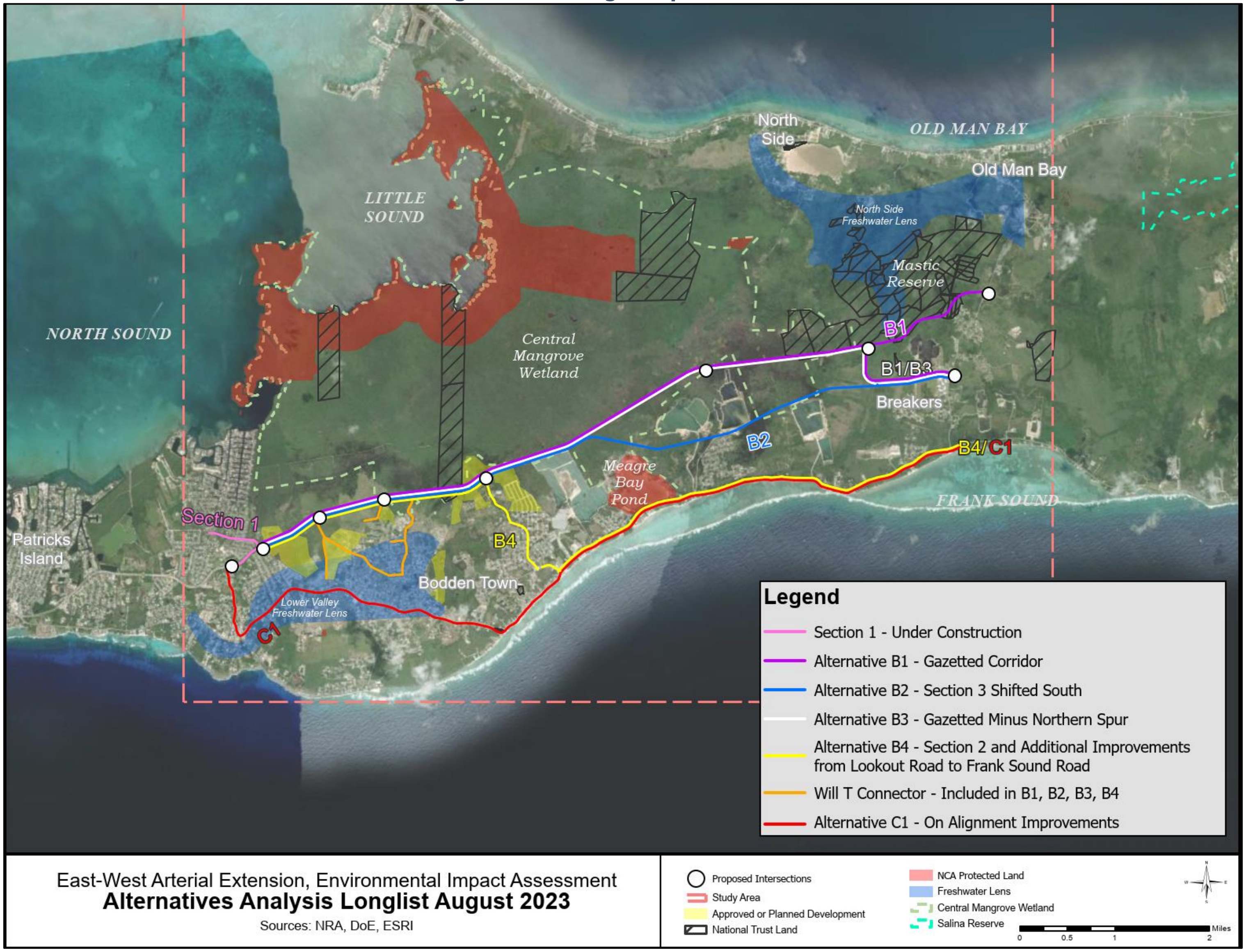


Table 5-1: Longlist Evaluation Summary

CSFs and Constraints	Planned Infra. (No-Build)	B1	B2	B3	B4	C1
CSFs [max. 65]	10*	62	62	62	48	35
Environmental Constraints – Natural [max. 30]	30	9	17	12	18	20
Environmental Constraints – Social [max. 30]	30	24	28	28	19	10
Engineering Constraints [max. 10]	6	8	8	8	6	4
Cumulative Evaluation:	**76 out of 120**	**103 out of 135**	**115 out of 135**	**110 out of 135**	**91 out of 135**	**69 out of 135**

*Max. 50 for the Planned Infra. (No-Build) CSFs

The EWA EIA Steering Committee met on August 23rd and 24th of 2023 to discuss the Longlist Alternatives Evaluation. Below are the conclusions discussed in identifying the alternatives for further studies in the Shortlist Evaluation.

- Planned Future Roadway Infrastructure (No-Build) Alternative: The Planned Future Roadway Infrastructure Alternative (No-Build) is to be carried forward through the entire EIA evaluation process per the UK Greenbook guidance.
- Alternative B1: This alternative would not to be carried forward because it would result in potential direct impacts to sensitive environmental features including the Mastic Reserve thus resulting in the lowest ranking for environmental impacts. In addition, since there are other Build alternatives that would result in potentially less environmental impacts, Alternative B1 was not justified for further study in the Shortlist Evaluation.
- Alternative B2: This alternative was chosen to be carried forward to the Shortlist Evaluation due to its high ranking when meeting the CSFs while also providing the least potential impacts on Environmental and Social Constraints. This alternative also had the highest overall cumulative ranking.
- Alternative B3: This alternative was chosen to be carried forward to the Shortlist Evaluation due to having less potential environmental impacts than Alternative B1 and accruing the second highest cumulative ranking.
- Alternative B4: This alternative was chosen to be carried forward to the Shortlist Evaluation due to its ability to incorporate a new roadway section while also utilising the existing roadway corridors. It also had the highest [least impactful] ranking in evaluating the potential environmental impacts.

- Alternative C1: This alternative would not be carried forward based on its inability to meet the CSFs and the anticipated numerous Social Impacts along with its inability to address the numerous engineering constraints. This alternative scored the lowest in both subject areas and resulted in the lowest overall cumulative ranking.

The Ministry of Planning, Agriculture, Housing, and Infrastructure (PAHI-TD) provided a directive memorandum on September 5, 2023 for inclusion of Alternative B1 within the shortlist of alternatives (**Appendix B - Ministry of PAHI Response to Longlist Alternatives Evaluation**). The directive notes that Alternative B1 is equally important as the No-Build and that exclusion of Alternative B1 would deny decision makers critical information on the originally gazetted alignment. Therefore, the final Shortlist of Alternatives includes:

- Planned Future Roadway Infrastructure (No-Build)
- Alternative B1
- Alternative B2
- Alternative B3
- Alternative B4

5.3 Shortlist of Alternatives

The Shortlist of Alternatives included four future Build alternatives, depicted in **Figure 5-4**, and the Future No-Build. It encompasses **Step 4** of the Alternatives Analysis Process discussed in **Section 5.1**.

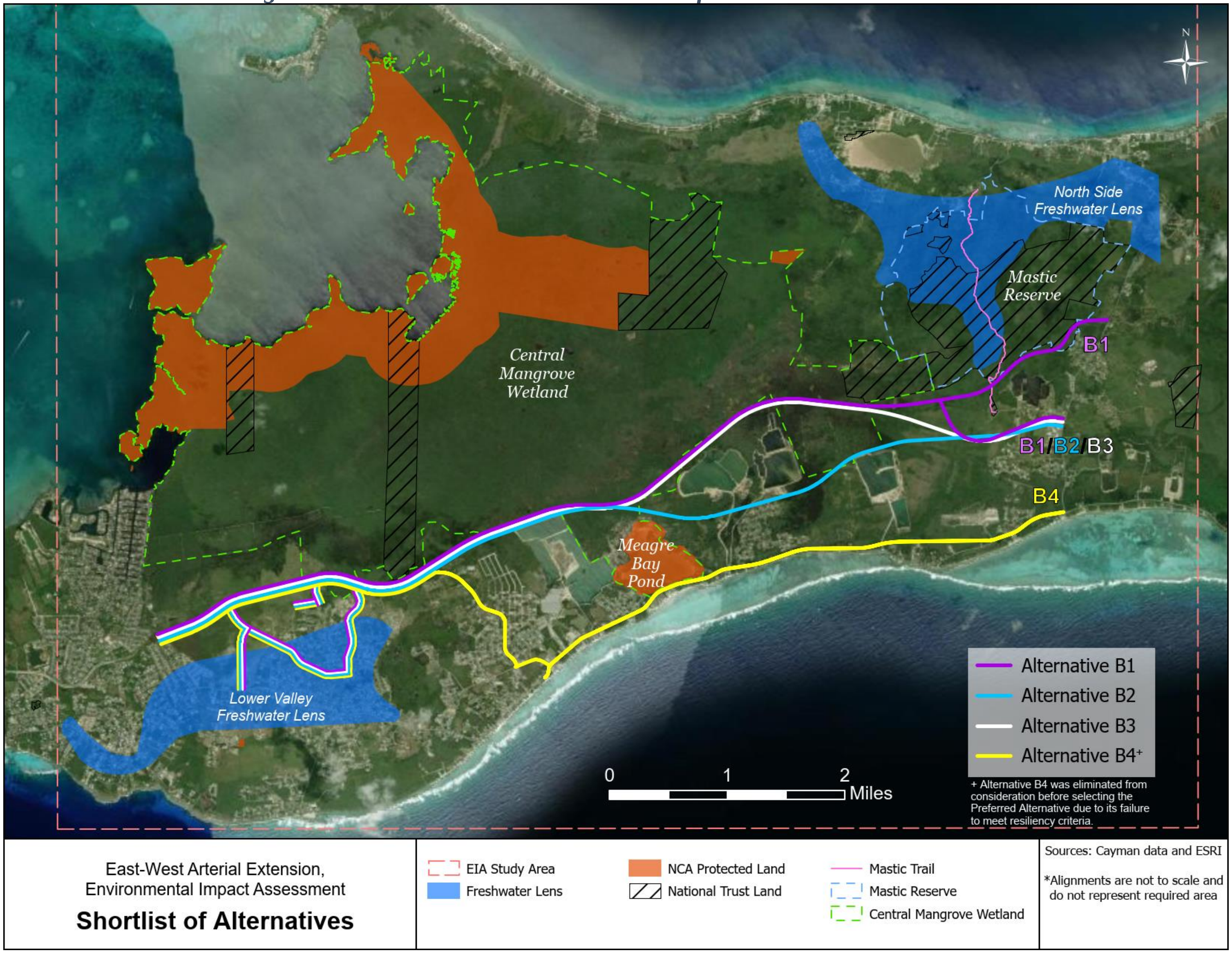
The four future Build alternatives and the Future No-Build were described in the Shortlist Alternatives Evaluation as follows:

5.3.1 Planned Future Roadway Infrastructure (No-Build)

The Planned Future Roadway Infrastructure (No-Build) Alternative describes a scenario under which the EWA Extension is not undertaken. The No-Build scenario is included as a benchmark from which to evaluate and compare the impacts of other alternatives. The difference between No-Build and Build conditions is that the Build conditions will include the proposed project-specific alternatives. The No-Build scenario also:

- Encompasses future year land use assumptions within and around the project study area. Future land use reflects the growth in population, households, and employment.
- Includes planned improvements to the island roadway network independent of Build alternatives B1, B2, B3, and B4. These planned improvements have been included as part of future year traffic evaluations but not evaluated for environmental or social impact as the CIG is planning these improvements as independent projects.

Figure 5-4: Alternatives Carried Forward for the Shortlist Evaluation



5.3.2 Build Alternatives

The proposed corridor width for the new roadway construction for the Build alternatives is 220 ft (67 m) along the primary east-west corridor and 41 ft (12.5 m) along the Will T Connector. This 220-ft corridor width allows for the area needed to accommodate a variety of features including roadway travel lanes and shoulders, transit transportation lanes, a pedestrian sidewalk, a micromobility path, lighting, utilities, and a solar panel canopy. The transit transportation lanes, lighting, utilities, and solar panel canopy are not within the ambit of the NRA and their inclusion within the corridor is dependent on the appropriate responsible entity. This corridor width also allows for elevating the vertical roadway profile from the existing ground profile to accommodate a roadway surface elevation above the chosen parameter of a 50-year storm event. These considerations were in support of the CSFs (**Section 2.1**). Additional information regarding the hydrology evaluation can be found in **Appendix E – Shortlist [Alternatives] Evaluation: Attachment H – Hydrology & Drainage – Assessment of Alternatives**.

The EIA studies examined Section 2 and Section 3 of the four shortlisted Build alternatives, B1, B2, B3, and B4. Section 2 is common between the four shortlisted alternatives; it proposes a new section of roadway located from Woodland Drive to Lookout Road and includes a series of improved roadways described as the Will T Connector. As a result of information collected on natural and human features within the study area following the Longlist [Alternatives] Evaluation, the project corridor within Section 2 was shifted further to the south near Lookout Road to avoid impacts to NT-owned CMW land.

Build alternatives B1, B2, and B3 propose new roadway construction for Section 3. The proposed new roadway would have the same 220 ft (67 m) wide corridor and features as described for Section 2. Alternative B4 would primarily follow the existing path of Bodden Town Road for Section 3, and due to the existing built environment along this area, a narrower corridor with different accommodations was proposed for Alternative B4.

Details regarding the components of the proposed corridor can be found in **Appendix E – Shortlist [Alternatives] Evaluation: Attachment B - Engineering – Assessment of Alternatives**.

Build alternatives B1, B2, B3, and B4 also include a series of improved roadways described as the Will T Connector. These roadways would provide access to the common Section 2 of Build alternatives B1, B2, B3, and B4. The proposed corridor width for the Will T Connector is 41 ft (12.5 m) including a single travel lane in each direction, bike lanes on both sides of the roadway, and concrete curb and gutter on both sides of the roadway. A sidewalk would also be included along one side of the roadway.

5.3.3 Alternative B1

Alternative B1 was developed to generally follow the corridor that was 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 western limit for Alternative B1 begins at the terminus of Section 1 of the EWA (currently under construction) in the area of Woodland Drive and travels east to Frank Sound Road. Alternative B1 includes two segments of new roadway with two separate connections to Frank South Road. Alternative B1 has an estimated 9.7 mi (15.5 km) of mainline corridor length.

Following the Longlist [Alternatives] Evaluation, the location of segments of Alternative B1 were shifted slightly to the south in areas to avoid impacts to NT-owned Mastic Reserve parcels. In addition, the location of Alternative B1 was also shifted slightly north in areas to avoid encroachment on active quarries. A figure showing the originally gazetted corridor, and the modifications made to Alternative B1 can be found in **Appendix E – Shortlist [Alternatives] Evaluation: Attachment B - Engineering – Assessment of Alternatives**.

5.3.4 Alternative B2

Alternative B2 has the same western limit as Alternative B1. It begins at the terminus of Section 1 of the EWA (currently under construction) in the area of Woodland Drive and travels east with the construction of a new roadway to Frank Sound Road. Instead of running north above the quarries like Alternatives B1 and B3, Alternative B2 runs south beneath the quarries. It lacks the northern connection to Frank Sound Road described for Alternative B1, and it ties in at Frank Sound Road at the same place where Alternative B1's southern connection ties in. Alternative B2 has an estimated 7.6 mi (12.2 km) of mainline corridor length.

5.3.5 Alternative B3

Alternative B3 has the same western limit as Alternatives B1 and B2. It begins at the terminus of Section 1 of the EWA (currently under construction) in the area of Woodland Drive and travels east with the construction of a new roadway to Frank Sound Road. Within Section 3 Alternative B3 follows the same location as Alternative B1 until reaching the Mastic Reserve. At this point, Alternative B3 shifts farther south to connect to Frank Sound Road. Alternative B3 has an estimated 7.9 mi (12.7 km) of mainline corridor length.

5.3.6 Alternative B4

Alternative B4 has the same western limit as Alternatives B1, B2, and B3. It begins at the terminus of Section 1 of the EWA (currently under construction) in the area of Woodland Drive and travels east to connect to Frank Sound Road at Bodden Town Road's current connection. Alternative B4 follows the same location as Alternatives B1, B2, and B3 for Section 2 between Woodland Drive and Lookout Road. Within Section 3 Alternative B4 primarily follows the existing roadways of Lookout Road and Bodden Town Road. Alternative B4 has an estimated 2.6 mi (4.2 km) of new corridor length within Section 2 and an estimated 5.8 mi (9.3 km) of upgrades to the existing roadway network within Section 3.

5.3.7 Elimination of Alternative B4 from Consideration

Due to Alternative B4 failing to meet resiliency criteria without significant social impacts and engineering constraints, the NRA and EAB concurred with the elimination of Alternative B4 from further evaluation on March 14, 2024. The full description of Alternative B4's elimination from consideration can be found in **Appendix E – Shortlist [Alternatives] Evaluation: Section 3.6.1**. A summary of Alternative B4's failure to meet resiliency criteria without significant social impacts and engineering constraints is as follows:

- Section 3 of Alternative B4 along the southern coast would require an elevation or beach berm of over 20 ft (6 m) above mean sea level due to the high risk of the roadway being blocked by sand during a severe event with wave overtopping.

- Impacts from the required elevation or beach berm could include property acquisitions, severing of access, viewshed impacts, and impacts to cross street and driveway connections.
- Alternative B4 only provides an alternate route west of Lookout Road in the event of road closures or emergency events.
- Adding travel lanes to the on-alignment improvements east of Lookout Road would likely increase the road's traffic volume and the likelihood of crashes along the existing road.

5.3.8 Evaluation Summary

Nine technical studies were conducted to evaluate the future Build alternatives and were appended to the Shortlist [Alternatives] Evaluation as technical reports. These technical studies included:

- Traffic [Transportation and Mobility]
- Engineering
- Socio-Economic
- Noise
- Geo-Environmental
- Terrestrial Ecology
- Cultural and Natural Heritage
- Hydrology and Drainage
- Greenhouse Gases (GHG)

In addition, a comprehensive Cost-Benefits Analysis (CBA) which incorporates elements from the technical studies, was also completed.

The studies conducted for each of the three future Build alternatives B1, B2, and B3 as well as the Future No-Build included a comprehensive analysis of the established CSFs and the estimated direct impacts to environmental and social features along with evaluations of the engineering features. The alternatives were evaluated quantitatively, qualitatively, and monetarily (where applicable) using the UK's Transport Appraisal Guidance (WebTAG) guidance.

The following describes the conclusions of this Shortlist [Alternatives] Evaluation, including the similarities and differences between each of the Build alternatives. Additional details can be found in **Appendix E - Shortlist [Alternatives] Evaluation**.

From a CSFs and Engineering Constraints perspective, all three Build alternatives B1, B2 and B3 are comparable due to design similarities by providing an alternate route in the event of road closures that shifts most east-west traffic volume to the new EWA facility. This change in travel movement is also projected to significantly reduce the number of conflict points, including driveways, cross-streets, and access points along the existing routes, thereby reducing the number of crashes. In addition, this new alternate corridor is projected to provide improved resiliency and opportunities for multimodal accessibility with separated/dedicated facilities for transit, pedestrians, bicycles, and other micromobility modes of travel. The proposed corridor width for Build alternatives B1, B2 and B3 also allows for the area needed to accommodate additional features including lighting, utilities, and a solar panel canopy that would not only provide electricity generation but also shade for the sidewalk and micromobility facilities. Even though some of these features, including the proposed dedicated transit lanes and the proposed solar panel canopy, are not within the ambit of the NRA, both components are projected to provide benefits. The solar panel canopy benefits (in terms of avoiding diesel fuel costs and carbon emissions) are expected to exceed the investment cost of purchasing, installing, and operating the proposed solar facility.

From a Social Impacts perspective, all three Build alternatives B1, B2 and B3 are comparable, providing an estimated Large Beneficial impact for socio-economics and a monetary disbenefit for noise.

From a Natural Environment Impacts perspective, Build alternatives B2 and B3 are estimated to result in the same overall qualitative rating of Moderate Adverse, whereas Alternative B1 is estimated to be the most impactful of the Build alternatives with an overall qualitative rating of Large Adverse.

From a CBA perspective, Build alternatives B2 and B3 both resulted in the highest B/C ratio of 1.3 (versus a B/C ratio of 1.2 for Alternative B1).

5.3.9 Selection of the Preferred Alternative

The EWA EIA Steering Committee met on May 7th, May 8th, and May 13th of 2024 to discuss the Shortlist [Alternatives] Evaluation. The EAB recommended Alternative B2 due to its lower overall quantitative impact on natural resources compared to the other Build alternatives (B1 and B3). See **Appendix E - Shortlist [Alternatives] Evaluation: Attachment K – EAB Preferred Alternative Recommendation** for additional details regarding EAB's recommendation. The NRA/ PAHI-TD recommendation was Alternative B3 for constructability reasons and to avoid disturbance to the trafficked area and residential and commercial routes. In addition, the NRA/PAHI-TD also viewed the Alternative B3 as providing a protective boundary between developed areas in the south and naturally preserved areas at the north but recognised that currently there is no legal or policy means to give effect to this. The PAHI-TD recommended Alternative B3 due to its higher GHG benefit, not having the potential impact of Alternative B2 on quarry operations, and lower impact on Cayman parrot habitat.

A High-Level Summary Report of the EWA EIA Study Findings for the Selection of a Preferred Alternative memorandum was provided to the Cabinet (**Appendix E - Shortlist [Alternatives] Evaluation: Attachment L – High-Level Summary Report of the EWA EIA Study Findings for the Selection of a Preferred Alternative**). On June 27th, 2024, Cabinet granted approval for the selection of **Alternative B3** as the Preferred Alternative. See **Appendix E - Shortlist [Alternatives] Evaluation: Attachment M – PAHI-TD Memorandum – Cabinet Approval of Preferred Route and Press Release** for the memorandum from the PAHI-TD Ministry noting the progress made to date on the EWA EIA and approval for selection of Alternative B3 as the preferred route.

<u>Planned Future Roadway Infrastructure (No-Build) Alternative:</u> The Planned Future Roadway Infrastructure Alternative (No-Build) is to be carried forward through the entire EIA evaluation process per the UK Greenbook guidance as a baseline of comparison.

<u>Alternative B1:</u> Alternative B1 will **not** be carried forward, as agreed by all members of the Project Steering Committee.

Alternative B2: Alternative B2, chosen by the EAB as the least impactful option, will **not** be carried forward.

Alternative B3: **Alternative B3 is chosen to be carried forward by Cabinet approval.**

5.4 Preferred Alternative (Proposed Project)

As described in **Section 5.3.3**, Alternative B3 was chosen to move forward as the Preferred Alternative for the EWA Extension EIA. The remainder of this ES will refer to Alternative B3 as the "Proposed Project" and assess potential effects from both the Proposed Project and Future No-Build conditions, where applicable. The Planned Future Roadway Infrastructure Alternative (No-Build) is to be carried forward through the entire EIA evaluation process for contextual purposes only and as a basis of comparison as per the UK Greenbook and Cayman Islands' EIA Directive guidance.

Appendix F.4 - Comparison to Original Gazetted Alternative depicts the Proposed Project compared to the 2005 Gazetted EWA Corridor. As part of the assessment of alternatives analysis process, the corridor was refined as technical studies information was collected. These refinements from the 2005 Gazetted EWA Corridor included:

- Shifting the location of the corridor further to the south to avoid right-of-way (ROW) acquisition from NT owned properties.
- Shifting the corridor where applicable to limit habitat fragmentation within the CMW.
- Shifting the location of the corridor to avoid active quarry encroachment.
- Removing the 1.5 mi (2.4 km) northern spur connection to Frank Sound Road within the Mastic Reserve and Mastic Trail.

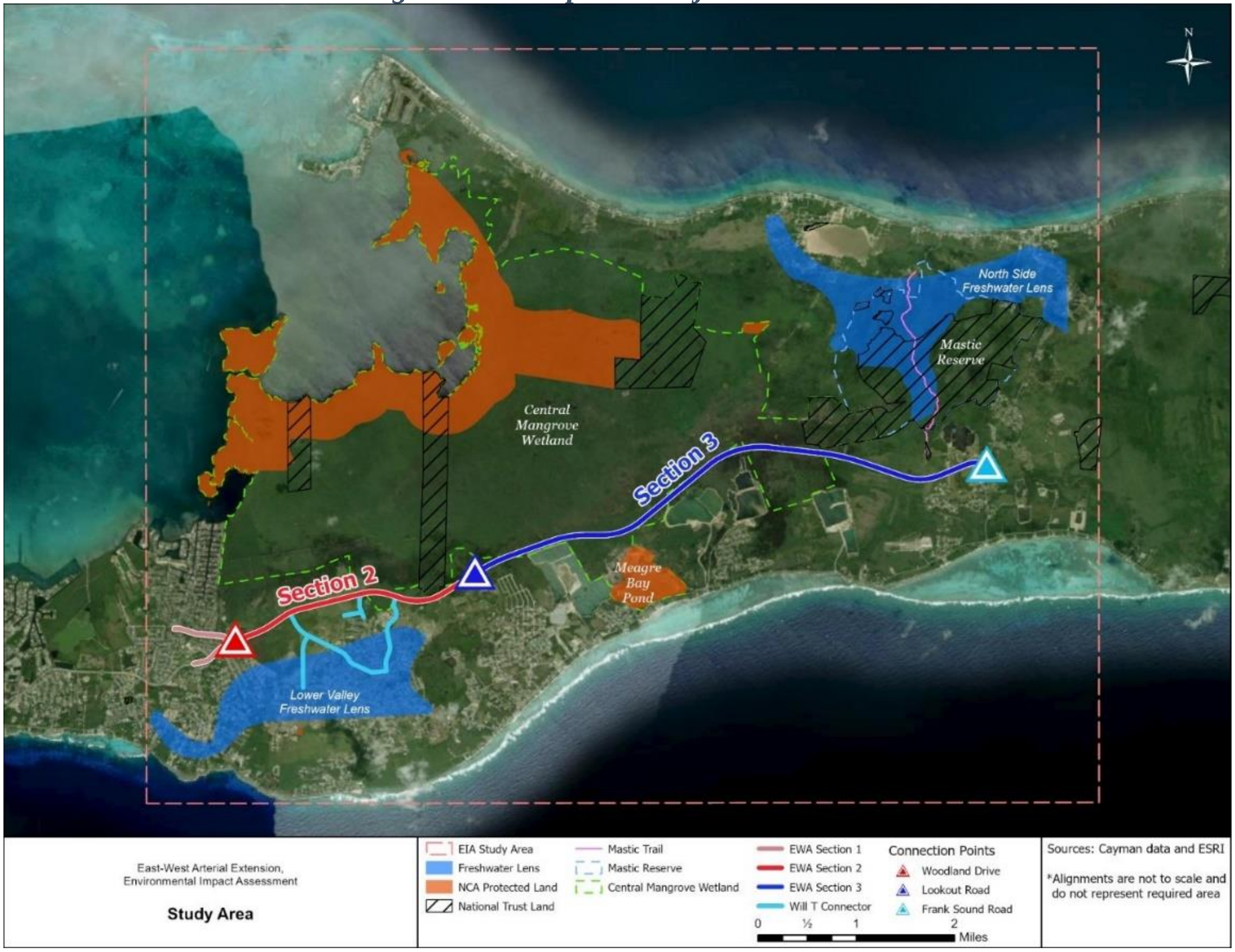
Descriptions of these Proposed Project refinements along with a detailed description of the Proposed Project engineering design features are included in **Chapter 6: Proposed Project – Engineering Features**.

6 Proposed Project – Engineering Features

This chapter presents detailed descriptions of the engineering features developed for the Proposed Project of the EWA Extension on Grand Cayman Island. As previously described in **Chapter 5: Assessment of Alternatives Analysis**, the Proposed Project was selected after an extensive evaluation of multiple alternatives, balancing engineering standards, environmental considerations, and local preferences. The primary goals of the Proposed Project are to enhance east-west connectivity, alleviate traffic congestion, and provide a sustainable, long-term transportation solution that accommodates the island's future growth and development.

The Proposed Project extends from the current terminus of Section 1 of the EWA, currently under construction, at Woodland/Agricola Drive and continues to Frank Sound Road in the east. The project also involves a series of proposed minor connector roadways collectively referred to as the Will T Connector. An overview of the corridor and its sections can be seen in **Figure 6-1** below.

Figure 6-1: Proposed Project Overview



Designed with future flexibility in mind, the project incorporates key features such as:

- Multiple vehicular travel lanes for general traffic;
- Dedicated transit lanes to support public transportation*;
- A micromobility path for lightweight vehicles like scooters, bicycles, and other small electric powered transportation devices;
- A sidewalk for pedestrians;
- A solar array over a section of the micromobility path and sidewalk*;
- Structures, such as bridges, culverts, pipes, spaced accordingly for maintaining normal hydrologic connectivity during storm events and reducing flood risks;
- Utility corridors for water, sewer, electricity, and telecommunications infrastructure*

**Note that these features are outside of the ambit of the NRA. The NRA will provide the ability for the corridor to accommodate these features.*

These features have been envisioned to be introduced in phases aligned with the needs and priorities anticipated throughout different horizon years, also referred to as build years. The build years have been defined as 2026, 2036, 2046, and 2060. Implementation of these features will vary between Section 2 and Section 3 for each of the build years. Special attention has been given to optimising the timing and placement of these features regarding environmentally sensitive areas along the corridor, cost effectiveness, and adjacent future development of the area. These features represent one potential vision for the future, and they are not the only way the corridor can be developed. As the island's public transportation system, traffic demands, and societal needs continue to develop, these features are also expected to adapt accordingly. This chapter contains descriptions of the following elements for the Proposed Project:

- Typical sections for anticipated build years (2026 to 2060),
- ROW needs and acquisition strategies,
- Preliminary cost estimates for both construction and ROW acquisition.

The design also includes the horizontal alignment, vertical profile, and intersection layouts, as well as proposed locations for bridge structures to maintain hydrologic connectivity and minimise impacts to sensitive areas. Three design options are examined: the Excellent Fit, the Good Fit, and the Acceptable Fit. These three options offer different costs and resiliency benefits. The initial design concept is the Excellent Fit, which is the most resilient and therefore most expensive option. The other two options lower the cost and remove some resiliency while still meeting the CSFs.

A series of roll maps for the 2026 build year, which feature plans and vertical profiles along with the conceptual locations of potential bridges and drainage connectivity pipes, are included in **Appendix F.1.1: Excellent Fit Corridor Roll Maps**. Bridge Structure Concept Plan Sheets showing a concept bridge level design can be found in **Appendix F.2: Bridge Structure Concept Plan Sheets**. Graphical typical sections for each build year, showing both roadway and bridge structures, are provided in **Appendix F.3.1: Excellent Fit Typical Sections** to offer a visual reference for the technical descriptions. Additionally, a map comparing the original gazetted corridor as well as existing environmental and geological features can be found in **Appendix F.4: Comparison to Original Gazetted Alternative**.

Throughout the design process, the project team prioritized environmental stewardship, carefully planning the Proposed Project alignment and construction considerations to best avoid and minimise impacts on wetlands, wildlife habitats, and cultural resources. For a detailed view of the adjustments made to avoid environmentally sensitive areas, refer to **Appendix F.4: Comparison to Original Gazetted Alternative**. These efforts include the recommendation to install pipes and culverts in wetland areas alongside fill placement.

This approach is designed to preserve natural hydrology and ensure uninterrupted water flow to the wetlands, preventing damming and minimising flooding throughout both the construction and operational phases of the project. An integrated engineering design approach was used to incorporate sustainability and future-proofing measures, by examining the Proposed Project in relation to future development and climate challenges, including rising sea levels and extreme weather events. Sea level rise was considered during the conceptual development of the Proposed Project. Analysis of the degree of effectiveness will be evaluated in the detailed design phase using relevant hydrologic and hydraulic modelling techniques and the most current information on the sea level rise forecast.

For the Proposed Project, it is estimated that sea levels could rise up to 1.64 ft (0.5 m) over the 50-year life of the corridor. Sea level rise was not included in the Road Flood Modelling and Roadway Drainage Openings report used to design the concept profile for the Proposed Project. This projected increase poses significant challenges to the design, which does not account for sea level rise in the planning of structure openings or roadway surface elevations.

As sea levels continue to rise, the freeboard below structure openings may be reduced to less than 3 ft (0.9 m), significantly impacting the safety and effectiveness of these structures during storm events. Furthermore, surge waters could begin to encroach on the travel lanes, especially along the lowest areas of the roadway surface. The lowest areas of the roadway surface are currently designed to remain dry at the edge of the travel lanes during a 50-year storm event. A 50-year storm event refers to a storm of a certain magnitude, such a hurricane or rainstorm, that on average is expected to occur at least once every 50-years (2% chance of occurring in any given year) and can be considered a significant storm event. While the road may still be passable at higher points during such events when accounting for sea level rise, the increasing frequency and severity of flooding could disrupt traffic flow and escalate maintenance costs.

To address these issues, it is imperative to incorporate further sea level rise considerations into the hydrologic and hydraulic analysis during the detailed design phase of the project. This analysis should guide the redesign of drainage systems, elevation of critical infrastructure, and selection of resilient construction materials that can withstand frequent inundation. Proactively adjusting the design to accommodate potential future sea level rise will help ensure that the Proposed Project corridor remains functional and safe throughout its operational lifespan, protecting it against the adverse effects of climate change and rising sea levels.

This chapter includes information on the following elements/features:

- Engineering design considerations, including typical sections, horizontal alignment, and vertical profiles, bridge structures concept;
- Drainage design, including conceptual pipe and culvert placement and potential stormwater management strategies;
- Environmental considerations, outlining potential mitigation strategies and sustainability practices;
- Construction considerations, focusing on strategies to minimise environmental disruption and ensure adherence to sustainability goals during the construction phase, such as erosion control, water management, and wildlife protection measures;

- Cost estimates, providing a conceptual level breakdown of estimated construction and ROW acquisition expenses;
- Value Engineering and Future Cost Reduction Considerations, identifying potential cost-saving measures during the design and construction phases, as well as strategies to reduce maintenance and operational costs over the project's lifecycle. These efforts could include material selection, construction sequencing, and innovative engineering solutions that provide long-term benefits;
- Future steps required to advance the project into detailed design and implementation, including geotechnical investigations, and detailed survey work, and
- Community and Stakeholder Engagement is discussed as a suggested early step to keep the public continuously informed of the project's development, goals, and attributes and to aid in identifying public concerns and priorities through different means such as public meetings, and online updates and feedback channels.

By advancing the Proposed Project, the NRA will create a modern and resilient transportation connection that enhances mobility, supports economic growth, and best preserves the unique environment and cultural heritage of Grand Cayman.

6.1 Corridor Features and Timeline

As first noted in the introduction, the Proposed Project extends from the current terminus of Section 1 of the EWA, currently under construction, at Woodland/Agricola Drive and continues to Frank Sound Road in the east. The corridor has been categorized into two sections. Section 2 starts at the beginning of the project, the terminus of Section 1, as mentioned, and ends at a proposed intersection with Lookout Road – it spans approximately 2.84 mi (4.57 km). Section 3 begins where Section 2 ends and then terminates at the end of the corridor with Frank Sound Road – it spans approximately 5.08 mi (8.18 km).

As shown in **Table 6-2** and **Table 6-3**, construction of the Proposed Project corridor is assumed to occur in phases, with the horizon year set at 2060**.** The initial phase, anticipated for 2026, would include two vehicular travel lanes**,** one in each direction, for both Section 2 and Section 3, as illustrated in **Figure 6-2**. These sections would also feature highway lighting. From this first stage, the project meets what is described as a CSF, which are objectives that are vital to the project's success, representing the main goals that the Proposed Project aims to achieve. The creation of an alternative travel route to the existing two-lane Bodden Town Road is one of the CSFs for the Proposed Project and is achieved through initial establishment of the two-lane roadway facility in 2026 that is likely to reduce commuter and tourist travel times across the island. The two-lane section would also include a median with barrier and wide, outside shoulders which can be used as an emergency lane or space for troubled vehicles to clear the travel way. Many of the CSFs are described in more detail within **Chapter 7: Transportation and Mobility**. A list of the CSFs for the project can be found in **Table 6-1**.

Table 6-1: Critical Success Factors List – Engineering Evaluation

Criteria	Target
a. **Alternate Routes:** Create an alternative travel route to the existing two-lane Bodden Town Road	Provide an alternative roadway facility to accommodate travel in the event of a roadway closure (**Section 6.1: Corridor Features and Timeline)**
b. **Existing Roadway Resiliency:** Improve resiliency of the existing roadway travel route between North Side/East End and George Town/West Bay.	Improve resiliency of the travel route to flooding from sea level rise, storm surge, wave overtopping, and rainfall (**Section 6.6.5 Vertical Grades, Cross Slopes, and Roadway Profiles**)
c. **Future Traffic Demand:** Support current and future traffic demand.	Provide travel lanes necessary to accommodate projected trips/vehicles (**Chapter 7: Transportation and Mobility**) Provide controlled access points to enter roadway facility (**Section 6.6.9: Intersections)**
d. **Commuter Travel Times:** Improve travel time between North Side/East End and George Town/West Bay	Improve projected travel time between North Side/East End and George Town/West Bay (**Chapter 7: Transportation and Mobility)**
e. **Utilities:** Accommodate utility expansion (electricity, fibre, water, central sewage) *	Establish area adjacent to roadway to provide for utility needs. (**Section: 6.6.11: Utilities)**
f. **Public Transit Access:** Provide opportunity to safely accommodate and expand public transportation *	Establish public transportation facilities and improve bus travel time reliability. (**Section 6.6.8: Future Multimodal Facilities**)
g. **Tourist Travel Times:** Reduce tourism travel time between North Side/East End and George Town	Reduce travel times between Owen Roberts International Airport and the North Side (**Chapter 7: Transportation and Mobility)** Reduce travel time between George Town Cruise Port and Bodden Town/North Side/East End (**Chapter 7: Transportation and Mobility)**
h. **Safety:** Improve safe vehicular travel by reducing roadway conflict points	Reduce the number of Cross Street Intersections along the primary east-west corridor (**Section 6.6.9: Intersections**) Reduce the number of Driveway Access Points along the primary east-west corridor (**Section 6.6.9: Intersections**)
i. **Pedestrian and Bicycle Access:** Provide opportunity for enhanced and safe pedestrian and bicycle travel	Establish dedicated pedestrian and bicycle facilities adjacent to vehicular travel lanes (**Section 6.1.3: Will T Connector** and **Section 6.6.8: Future Multimodal Facilities**)

**These criteria are to provide opportunities to accommodate these features. It is outside the ambit of the NRA to provide utilities or public transportation.*

For Section 2, additional features anticipated by 2036 include dedicated transit lanes, a sidewalk, a micromobility path, utilities, a solar panel canopy, and highway lighting, as shown in **Figure 6-3**. By 2046, additional vehicular travel lanes are anticipated to be incorporated, as shown in **Figure 6-4**, while no further features are anticipated for 2060, as indicated in **Figure 6-5**.

In Section 3, the 2036 plan includes dedicated transit lanes, utilities, and highway lighting (**Figure 6-3**). Sidewalk, micromobility path, and the solar panel canopy would be phased in as needed. By 2046, these additional features—sidewalk, micromobility path, and the solar panel canopy—are anticipated to be fully incorporated (**Figure 6-4**). In 2060, additional vehicular travel lanes are also anticipated for this section (**Figure 6-5**).

Table 6-2: Proposed Project – Section 2 Timeline for Components

Typical Section Components	2026	2036	2046	2060**
Number of Travel Lanes	2	2	4	4
Number of Dedicated Transit Lanes*		2	2	2
Sidewalk		✓	✓	✓
Micromobility Path		✓	✓	✓
Utilities*		✓	✓	✓
Highway Lighting*	✓	✓	✓	✓
Solar Panel Canopy *		✓	✓	✓
**Note that these features are outside of the ambit of the NRA. The NRA will provide the ability for the corridor to accommodate these features.* ***Number of travel lanes based on Medium/ "core" land use/population growth scenario described in Chapter 7: Transportation and Mobility.*				

Table 6-3: Proposed Project – Section 3 Timeline for Components

Typical Section Components	2026	2036	2046	2060**
Number of Travel Lanes	2	2	2	4
Number of Dedicated Transit Lanes*		2	2	2
Sidewalk		Phased as Required	✓	✓
Micromobility Path		Phased as Required	✓	✓
Utilities*		✓	✓	✓
Highway Lighting*	✓	✓	✓	✓
Solar Panel Canopy*		Phased as Required	✓	✓
**Note that these features are outside of the ambit of the NRA. The NRA will provide the ability for the corridor to accommodate these features.* ***Number of travel lanes based on Medium/ "core" land use/population growth scenario described in Chapter 7: Transportation and Mobility.*				

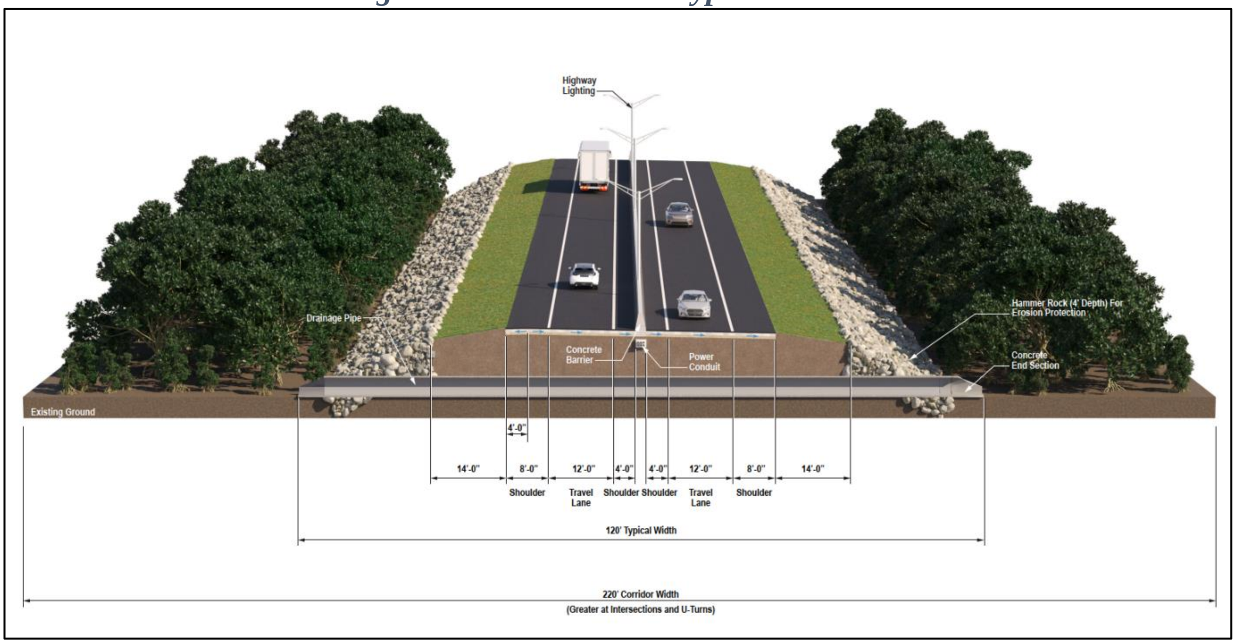
Typical sections depicting the progression of travel lanes and other features for the Proposed Project are shown in **Figures 6-2 through 6-5**. Larger versions of these figures are included in **Appendix F.3.1: Excellent Fit Typical Sections**. The typical sections were developed with a conservative approach in terms of estimated property disturbance and environmental impacts. For example, the roadway fill slopes (foreslopes) beyond the pavement edges are designed with a 1V:6H slope, which is flatter and thus recoverable. This design allows vehicles which would veer off of the roadway to regain control and return to the roadway. Slopes between 1V:6H and 1V:4H are considered recoverable, while slopes between 1V:4H and 1V:3H are classified as non-recoverable**,** meaning vehicles that leave the roadway typically reach the bottom of the slope and are less able to return.

The embankment slope and its height are critical in determining whether barrier protection is necessary. Roadways with higher traffic volumes and steep embankments may require roadside barriers, depending on the embankment height.

6.1.1 Roadway Features

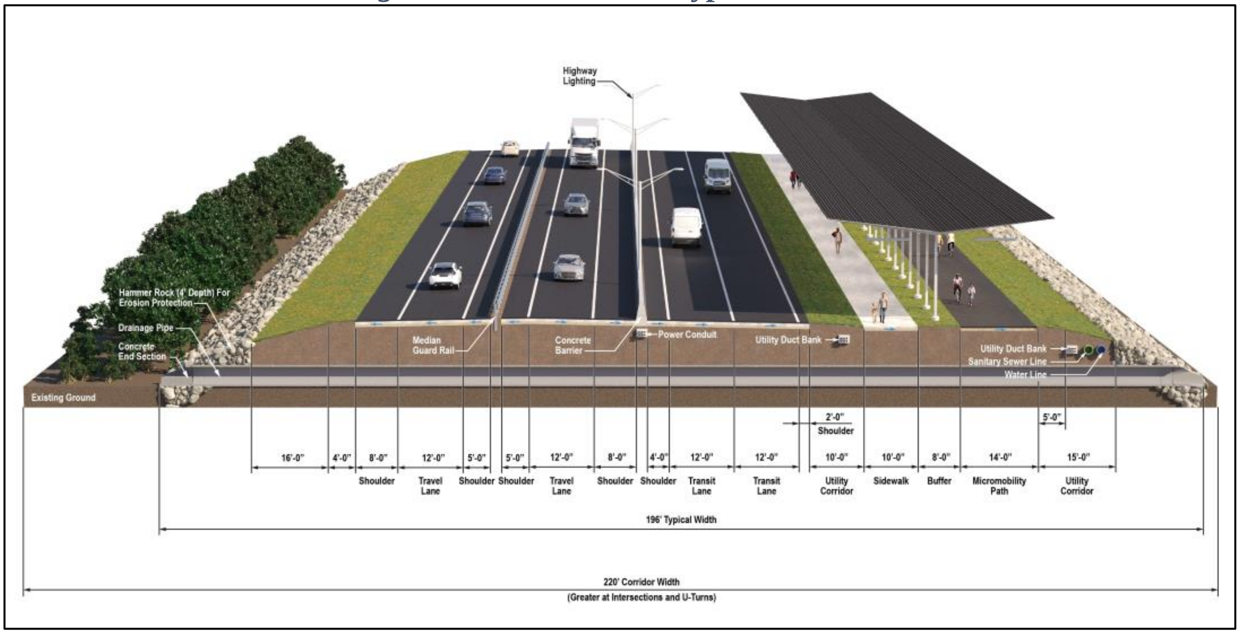
The roadway of the mainline of the corridor will see several features introduced throughout the previously outlined build years. Renditions of each build year can be seen in the figures below.

Figure 6-2: Year 2026 – Typical Sections

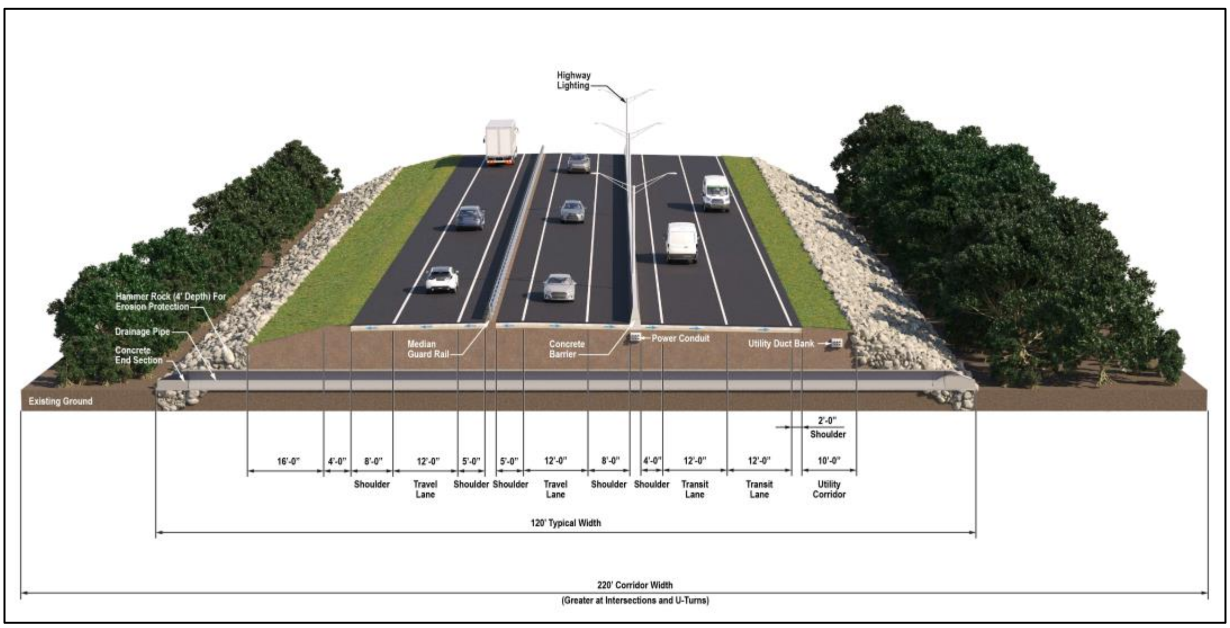


Proposed Project – Sections 2 and 3 (Woodland Drive to Frank Sound Road)
Includes two travel lanes (one in each direction), shoulders, median barrier, and highway lighting.

Figure 6-3: Year 2036 – Typical Sections

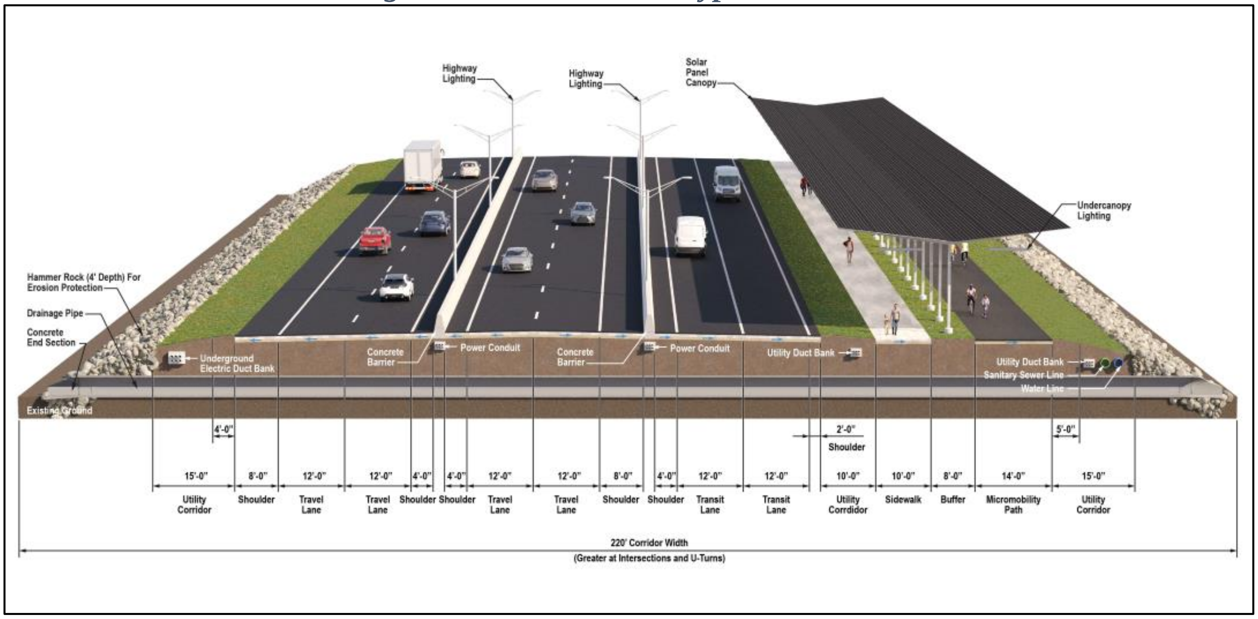


Proposed Project – Section 2 (Woodland Drive to Lookout Road)
Proposed Project – Section 3 (Lookout Road to Frank Sound Road as Needed)
Includes two travel lanes (one in each direction), shoulders, median barrier, highway lighting, transit lanes, sidewalk, micromobility path, solar array, and utility corridors.



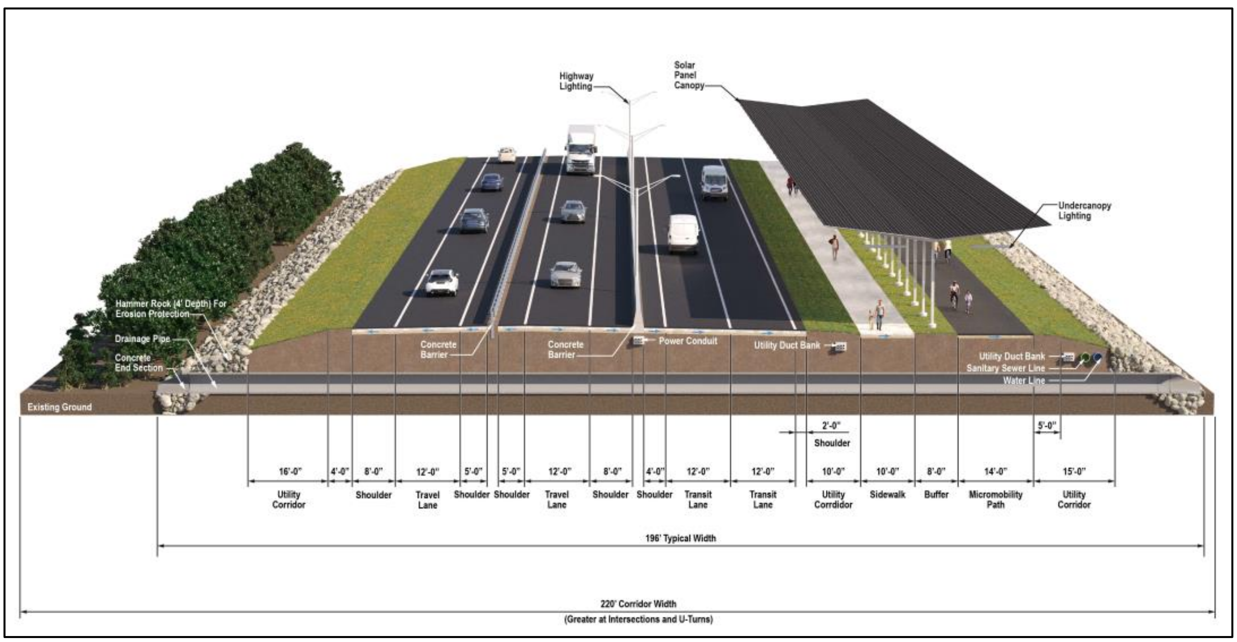
Proposed Project – Section 3 (Lookout Road to Frank Sound Road)
Includes two travel lanes (one in each direction), shoulders, median barrier, highway lighting, transit lanes, and a utility corridor.

Figure 6-4: Year 2046 – Typical Sections



Proposed Project – Section 2 (Woodland Drive to Lookout Road)

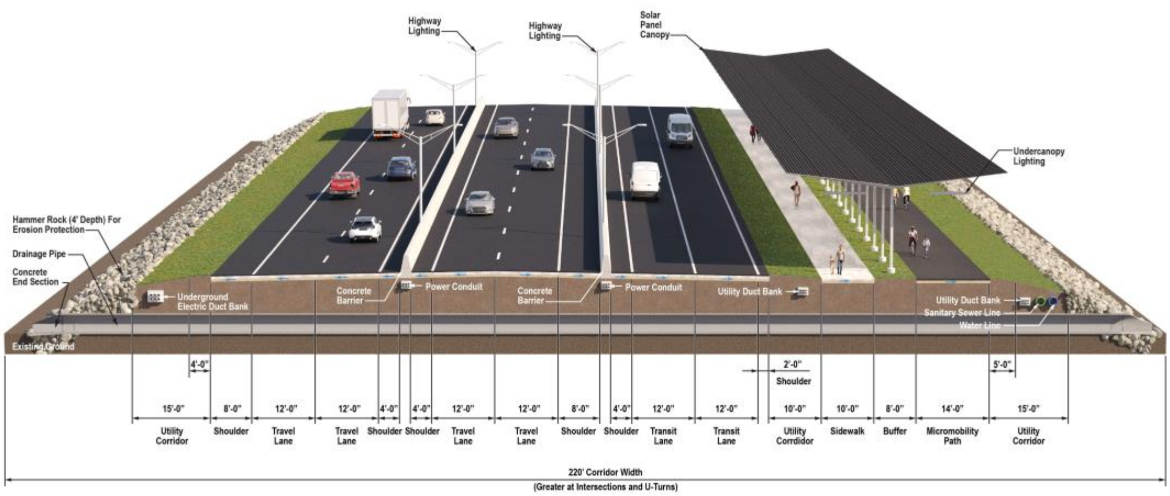
Includes four travel lanes (two in each direction), shoulders, median barrier, highway lighting, transit lanes, sidewalk, micromobility path, solar array, and utility corridors.



Proposed Project – Section 3 (Lookout Road to Frank Sound Road)

Includes two travel lanes (one in each direction), shoulders, median barrier, highway lighting, transit lanes, sidewalk, micromobility path, solar array, and utility corridors.

Figure 6-5: Year 2060 – Typical Sections



Proposed Project – Sections 2 and 3 (Woodland Drive to Frank Sound Road)
Includes four travel lanes (two in each direction), shoulders, median barrier, highway lighting, transit lanes, sidewalk, micromobility path, solar array, and utility corridors.

As can be seen from the figures above, additional travel lanes are introduced to the segments throughout the build years as travel demand warrants the need. A CSF of the project is to support current and future traffic demands, which is achieved through the introduction of additional lanes at different phases. Refer to **Chapter 7: Transportation and Mobility** for further discussion on future travel demand and the need for additional travel lanes at different points in time.

6.1.2 Bridge and Culvert Design Features

As previously discussed, another important design element of the Proposed Project is the incorporation of bridge and/or culvert structures to maintain hydrologic connectivity and minimise impacts to sensitive environmental features. Various engineering solutions are available to achieve these goals, including but not limited to:

- Short-span slab bridges
- Medium-span beam bridges
- Box culverts
- Three-sided culverts or pipe arches
- Pipe culverts

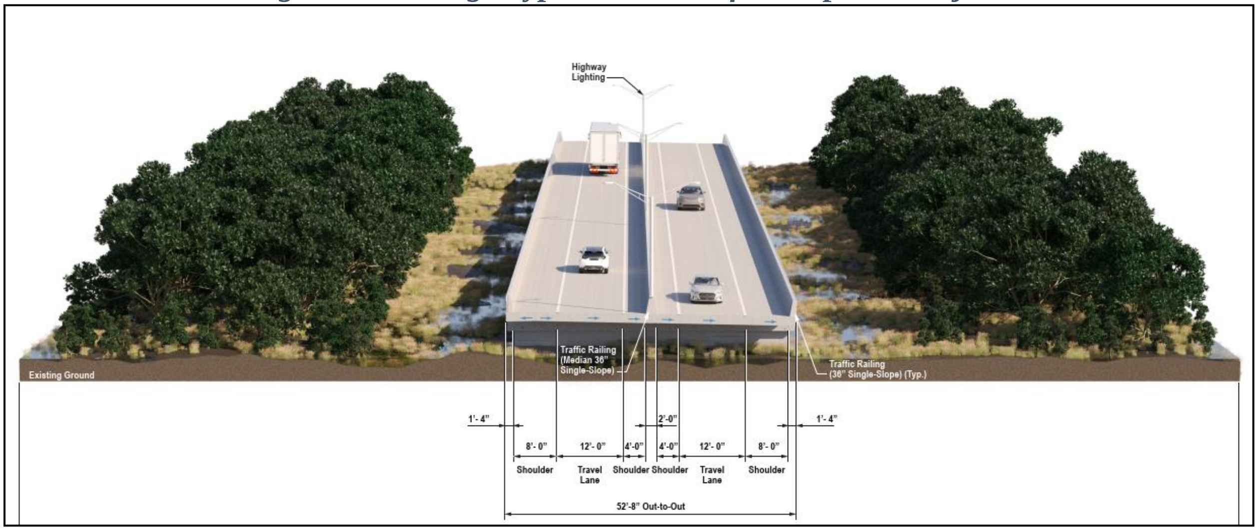
The choice of structure largely depends on the required opening size and the number of openings needed along the roadway embankment. For instance, solutions with smaller openings, such as pipe culverts, may require a larger number of openings spaced more frequently along the corridor.

At the conceptual design level, a conservative solution was selected, consisting of cast-in-place flat slab spans supported by reinforced concrete wall piers and abutments with spread footing foundations. This choice ensures structural integrity while accommodating the necessary hydrologic flow.

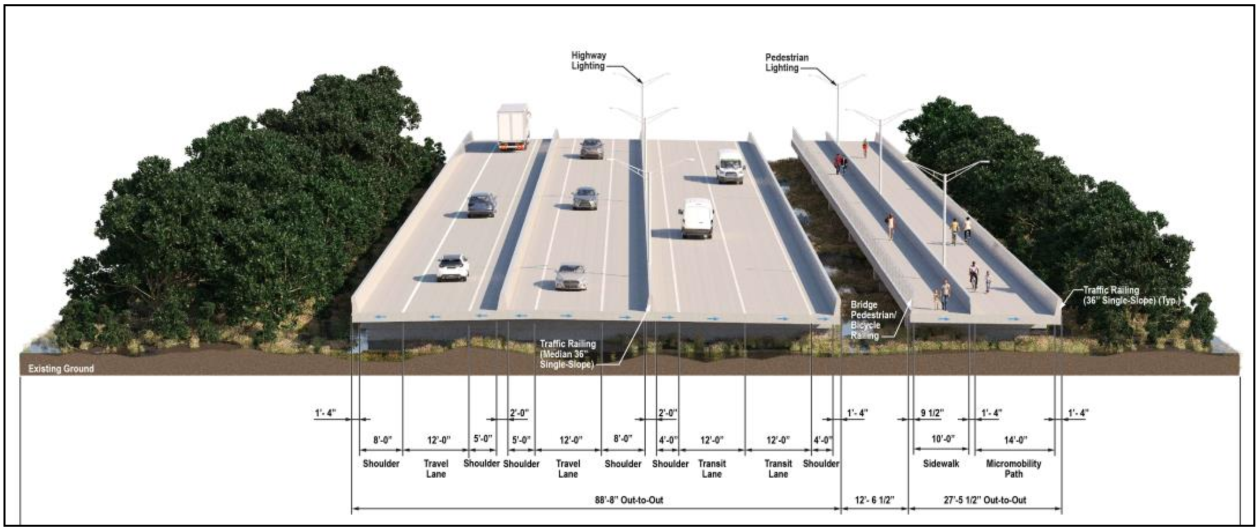
For detailed information regarding the number and size of the bridge openings estimated for the Proposed Project, refer to **Section 6.6.7: Hydraulic Structures** of this chapter. **Figure 6-6** illustrates a typical bridge section for the years 2026, 2036, 2046, and 2060. Larger versions of these figures can be found in **Appendix F.3.1: Excellent Fit Typical Sections**. Each bridge section is designed to accommodate the required number of travel lanes and additional features, such as pedestrian facilities, as described earlier.

At each bridge location, both the vehicular and pedestrian bridges would be constructed at similar elevations to meet the necessary hydraulic clearance, as detailed in **Section 6.6.7: Hydraulic Structures**. These bridges are also expected to have similar structural characteristics, including structure type, span lengths, and foundation depths, ensuring consistency across the Proposed Project.

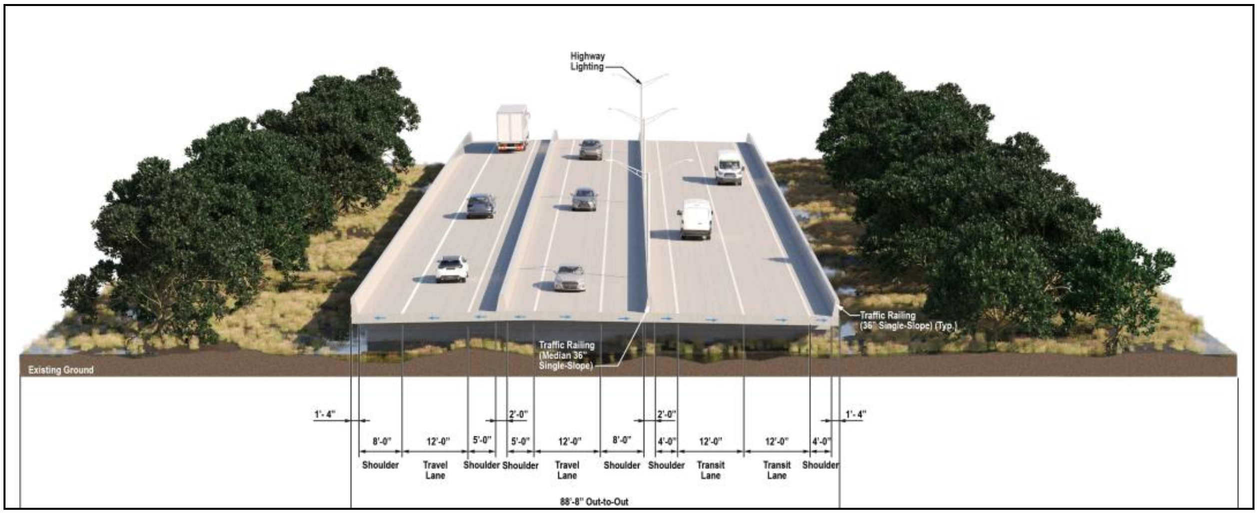
Figure 6-6: Bridge Typical Sections for Proposed Project



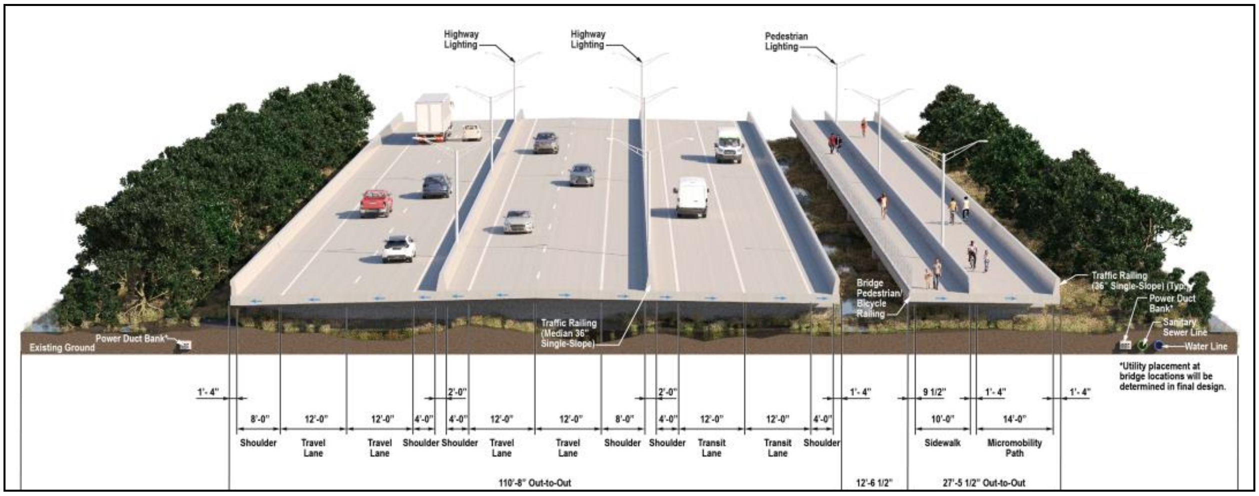
Year 2026 Bridge Typical Section for Proposed Project – Section 2 and Section 3



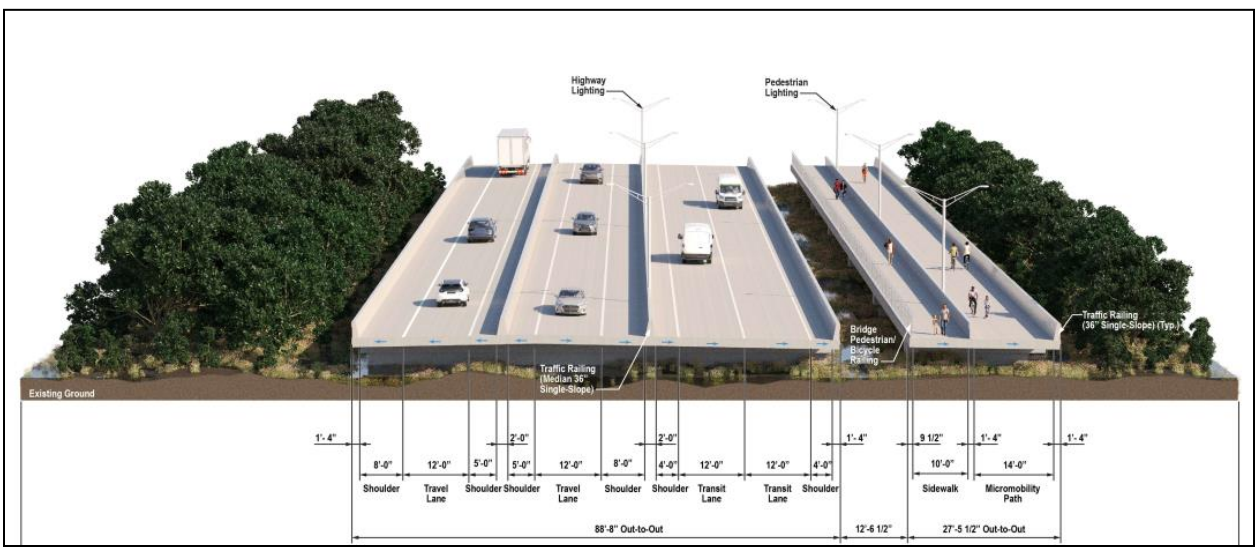
Year 2036 Bridge Typical Section for Proposed Project – Section 2



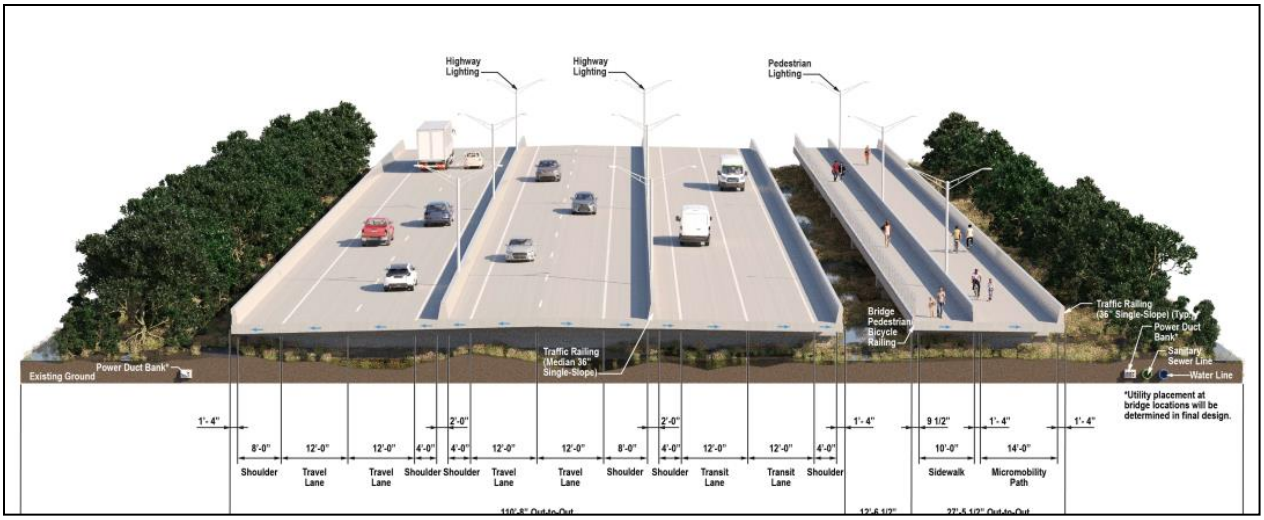
Year 2036 Bridge Typical Section for Proposed Project – Section 3



Year 2046 Bridge Typical Section for Proposed Project – Section 2



Year 2046 Bridge Typical Section for Proposed Project – Section 3



Year 2060 Bridge Typical Section for Proposed Project – Section 2 and Section 3

6.1.3 Will T Connector

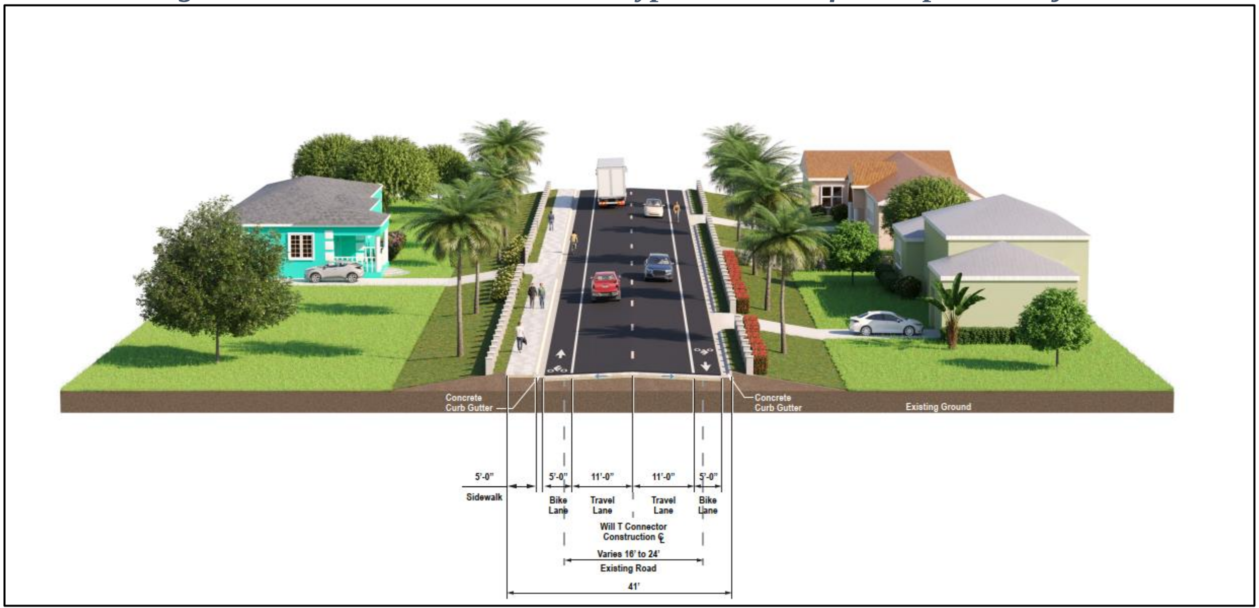
As previously mentioned, the Proposed Project includes a series of roadway improvements referred to as the Will T Connector, which will provide access to Section 2 of the Proposed Project. The Will T Connector is an integral part of the overall design and a typical cross-section is shown in **Figure 6-7**. A larger version of this figure can be found in **Appendix F.3.1: Excellent Fit Typical Sections**.

The proposed corridor width for the Will T Connector is 41 ft (12.5 m), which includes:

- A single travel lane in each direction
- Bike lanes on both sides of the roadway
- Concrete curb and gutter along both sides
- A sidewalk along one side of the roadway

The Will T Connector is designed to provide for smooth traffic flow and accommodate multimodal transportation, supporting vehicles, cyclists, and pedestrians. The construction of the Will T Connector is anticipated to begin in 2026, aligning with the phased development of the Proposed Project.

Figure 6-7: 2026 Will T Connector Typical Section for Proposed Project



6.2 Cost Estimate

6.2.1 Construction Cost

A comprehensive list of construction materials and activities required to build the Proposed Project was developed to estimate the construction costs. These items represent the key components that are quantifiable at this stage of the project and are expected to have the most significant impact on cost. The materials and activities were quantified for each anticipated build year phase (2026, 2036, 2046, and 2060 (2074 as a maintenance year)), and are detailed in **Tables 6-5** and **6-6**. Additionally, the cost estimate considers the nearly 50-year lifecycle of the facility, including ongoing maintenance and reconstruction.

For the roadway construction, the quantified items include:

- Excavation and embankment material
- Rock for slope stabilization
- Asphalt and rock for pavement
- Concrete for sidewalks, curbs, and medians
- Concrete barriers and guardrails
- Paint for pavement markings
- Highway lighting
- Drainage, erosion control, and stormwater management
- Roadway signing and sediment pollution control

A detailed breakdown of these construction costs can be found in **Appendix F.7.1: Excellent Fit Construction Cost Estimates**.

To determine the excavation and fill material requirements for the roadway embankment, a 3D model was created using Bentley OpenRoads Designer, a professional road design and modelling software. This model, combined with the surveyed terrain of the project area, provided a detailed view of how the proposed roadway would interact with the existing environment. For areas requiring peat removal, the volume was calculated using a vertical profile of the peat bottom layer, derived from test pit data collected along the original gazetted corridor. The resulting 3D model was used to calculate the excavation and fill volumes.

The preliminary pavement structure for the roadway was based on similar projects previously constructed by the NRA on the island. The total area of materials required for the pavement was quantified by overlaying the lane configuration onto the proposed alignments, creating measurable shapes that reflect the pavement surface. This method was also used to determine the quantities for curbs, sidewalks, the micromobility path, and median barriers. For specialty items such as highway lighting, spacing was calculated along the proposed alignment, with additional lighting considered at intersections.

The construction costs for proposed bridges were determined using a unit cost per square foot (metre) of bridge deck area. A conceptual bridge geometry was developed, and quantities for major cost items (such as concrete, reinforcing steel, traffic barriers, and slope protection) were calculated. This cost was applied to the proposed number of bridges for the Proposed Project. For future build years, where bridge widening would be required to add additional travel lanes, a 20% cost premium was applied to account for the higher costs of bridge widening compared to new construction.

Unit rate costs were developed using Heavy Construction Systems Specialists LLC HeavyBid, a professional construction estimating software widely used in the construction industry. The software compiled current labour, equipment, and material rates specifically for the Proposed Project. By generating crews and defining job task activities such as asphalt paving, bridge construction, drainage, and earthwork, the software applied production rates (based on past project data) to representative quantities. These production rates were then used to develop cost estimates for performing the required work. The software also calculated costs for fuel, equipment maintenance, labour overtime, workers' compensation, and tariffs, providing a comprehensive cost analysis for the project.

The estimated construction and maintenance costs for the Proposed Project by anticipated build year are summarized in **Table 6-5** and **Table 6-6** in both Cayman Islands Dollars (CI$) and U.S. Dollars (USD). Maintenance costs include ongoing maintenance of previously constructed components. For a more detailed cost breakdown, refer to **Appendix F.7.1: Excellent Fit Construction Cost Estimates**. It should be noted that all provided costs are reflective of a conservative proposed project and estimating process. Any changes/optimisation on the design in a detailed stage will have a direct reflection on the costs.

Table 6-4 presents a conceptual cost breakdown for Section 2 and Section 3 of the Proposed Project, segmented by Build-Year Phase and corresponding estimated construction years. This table illustrates one approach to estimating construction timeframes, factoring in varying production rates for different work items needed during construction. Notably, this table is not a construction schedule, which will be developed during the detailed design phase. The timeframe estimates here are distinct from other estimative efforts within the Environmental Statement (ES), particularly those concerning environmental impacts, which are more conservative with regard to the intensity of the impact on the evaluated resources. This breakdown serves to detail cost allocations for budgetary and other planning purposes. Comprehensive estimated costs for construction and maintenance by anticipated build year are summarized in **Tables 6-5** and **Table**

6-6, with further details available in **Appendix F.7.1: Excellent Fit Construction Cost Estimates**. It should be noted that all cost estimates are based on a conservative approach to the project's design and estimation process. Changes or optimizations made during detailed design stages will directly affect these costs.

Section 2 of the Proposed Project is an estimated 2.84 mi (4.57 km) in length and contains six (6) structures, each with a 330 ft (101 m) opening. Section 3 of the Proposed Project is an estimated 5.08 mi (8.18 km) in length and contains one (1) structure with a 330 ft (101 m) opening and eight (8) structures with a 150 ft (46 m) opening. The Will T Connector is an estimated 2.86 mi (4.60 km) and contains no modelled structures. The Will T Connector is included within the Section 2 construction costs and accounts for approximately 20% of total construction costs for Section 2.

Table 6-4: Estimated Construction and Maintenance Costs for the Proposed Project by Build-Year and Section (CI$ Million)

Build-Year Phase	Construction Year	Section 2 Total Cost by Year (CI$ Million)	Section 3 Total Cost by Year (CI$ Million)
2026	2026^	$23.45	-
	2027^	$40.63	-
	2028^	$55.90	-
	2029	-	$22.52
	2030	-	$34.54
	2031	-	$32.02
	2032	-	$24.80
	Build-Year Subtotal:	**$119.98**	**$113.88**
2036	2036	$29.31	-
	2037	$55.74	-
	2038	$61.62	-
	2039	-	$24.26
	2040	-	$33.01
	2041	-	$44.50
	Build-Year Subtotal:	**$146.67**	**$101.77**
2046	2046	$50.52	-
	2047	$18.54	-
	2048	-	$18.19
	2049	-	$38.59
	2050	-	$30.93
	Build-Year Subtotal:	**$69.06**	**$87.71**
2060	2060	$37.96	-
	2061	$36.26	-
	2062	-	$30.83
	2063	-	$78.27
	Build-Year Subtotal:	**$74.22**	**$109.10**
2074	2074^	$27.80	-
	2075	-	$48.79
	Build-Year Subtotal:	**$27.80**	**$48.79**
	Section Total:	**$437.73**	**$461.25**
Total Construction and Maintenance Cost for the Proposed Project (CI$ Million) = **$898.99**			

^Price includes construction/maintenance of the Will T Connector which accounts for approximately 10% of total construction costs for Section 2.

** Additional cost breakdown information for Section 2 and Section 3 is provided in **Appendix F.7.1** of this report.*

***Anticipated components included in each year are shown in **Tables 6-2** and **6-3** of this report.*

**** Note that all cost estimates provided are calculated in 2024 dollars, without adjustments for inflation. No inflation rates have been applied to account for future build years, and thus estimates reflect only current dollar values. Estimated costs have been rounded where appropriate.*

***** The costs presented reflect the concept design for the proposed project. It should be noted that all cost estimates are based on a conservative approach to the project's design and estimation process. Changes or optimizations made during detailed design stages will directly affect these costs.*

****** The construction duration for each section within a Build-Year Phase is a preliminary estimate based on a high-level analysis of production rates, labour capabilities, and equipment availability. These timelines may be adjusted if the number of crews and the availability of equipment are either increased or decreased for specific tasks.*

Table 6-5: Estimated Construction and Maintenance Costs for the Proposed Project (CI$ Million)

		New Construction Cost	Maintenance Construction Cost	Total Construction Cost Subtotal By Year	Potential Terrestrial Ecology Mitigation Cost	Contingency (%)	Total Construction Cost Subtotal by Year w/ Contingency	Total Estimated Construction Cost (CI$ Million)
Proposed Project Summary	**2026 Totals:**	$183.98	$0.00	$183.98	$10.91	20.00%	$233.87	$898.99
	2036 Totals:	$110.64	$89.86	$200.50	$6.55		$248.45	
	2046 Totals:	$67.62	$60.84	$128.46	$2.18		$156.77	
	2060 Totals:	$49.74	$100.84	$150.58	$2.18		$183.31	
	2074 Totals:	$10.10	$53.73	$63.83	$0.00		$76.59	

** Further cost breakdown information is provided in **Appendix F.7.1** of this report.*
***Anticipated components included in each year are shown in **Tables 6-2** and **6-3** of this report.*
**** Note that all cost estimates provided are calculated in 2024 dollars, without adjustments for inflation. No inflation rates have been applied to account for future build years, and thus estimates reflect only current dollar values.*
***** The costs presented reflect a concept level, conservative proposed project and estimating process. Estimated costs have been rounded where appropriate.*

Table 6-6: Estimated Construction and Maintenance Costs for the Proposed Project (US Dollars Million)

		New Construction Cost	Maintenance Construction Cost	Total Construction Cost Subtotal By Year	Potential Terrestrial Ecology Mitigation Cost	Contingency (%)	Total Construction Cost Subtotal by Year w/ Contingency	Total Estimated Construction Cost (USD Million)
Proposed Project Summary	**2026 Totals:**	$219.02	$0.00	$219.02	$12.99	20.00%	$278.41	$1,070.22
	2036 Totals:	$131.71	$106.97	$238.68	$7.79		$295.77	
	2046 Totals:	$80.50	$72.43	$152.93	$2.60		$186.63	
	2060 Totals:	$59.22	$120.04	$179.26	$2.60		$218.23	
	2074 Totals:	$12.02	$63.96	$75.98	$0.00		$91.18	

** Further cost breakdown information is provided in **Appendix F.7.1** of this report.*
***Anticipated components included in each year are shown in **Tables 6-2** and **6-3** of this report.*
****Note that all cost estimates provided are calculated in 2024 dollars, without adjustments for inflation. No inflation rates have been applied to account for future build years, and thus estimates reflect only current dollar values. USD have been converted from CI Dollars at a rate of $0.84 CI = $1.00 US; $1.00 CI = $1.19 USD.*
***** The costs presented reflect a concept level, conservative proposed project and estimating process. Estimated costs have been rounded where appropriate.*

6.2.2 Right-of-Way (ROW) Cost Estimate

To determine the cost of acquiring ROW for the construction of the Proposed Project, a corridor width of 220 ft (67.1 m) was used as the maximum disturbance area to assess potential impacts. In addition to this width, further areas outside the 220 ft (67.1 m) limit were considered based on 3D modelling of the corridor, allowing for the establishment of the maximum limits of disturbance (LOD) for the ultimate build year configuration in 2060.

For this analysis, a property and parcel map provided by the Lands & Survey Department was utilised to determine which parcels of land, and how much of each parcel, would be impacted by the Proposed Project. Each parcel was individually analysed, with some requiring partial acquisitions and others necessitating the acquisition of most or all the property.

In addition to land area, the presence of homes, commercial buildings, and other structures such as fences, walls, gates, and landscaping were factored into the property impact assessment. The effort required to demolish existing structures was also considered in the cost estimation. Further property considerations included the presence of wetlands, parrot habitat, and any potential impact to NT lands.

The Cayman Islands Land & Survey Department Valuation Office provided an estimated cost per square foot (metre) for the impacted properties, which also included costs associated with impacts to buildings and other structures. The impacts of the Will T Connector were also included in these calculations.

A detailed breakdown of the square foot (metre) impacts and costs for each impacted parcel can be found in **Appendix F.8: Parcel Impacts and Costs**.

Table 6-7 presents the estimated ROW costs for the Proposed Project.

Table 6-7: Estimated ROW Costs

	Proposed Project
Estimated Cost* 2024 CI$ Million (USD Million)	**$17.09** ($20.33)

Further cost breakdown information is provided in **Appendix F.5 of this report. Values shown for the Proposed Project include Will T Connector costs.*
*****US Dollars have been converted from CI Dollars at a rate of $1.00 CI = $1.19 US; $0.84 CI = $1.00 US.*

6.2.3 Total Costs

The overall estimated total costs for the Proposed Project were calculated by combining the estimated construction costs (as detailed in **Table 6-5** and **Table 6-6**) with the estimated ROW acquisition costs (as shown in **Table 6-7**). This includes potential costs for maintenance and rehabilitation through the horizon year 2074.

The total costs cover the major aspects of the Proposed Project, and the long-term sustainability, operational integrity, and land acquisition impacts were accounted for. These costs reflect that of a long-term project, staged in instalments over 50 years (average evenly distributed value of the project is approximately $18 million CI$ a year). As previously noted, the total costs of the project reflect a conservative conceptual design and a conservative estimating process that each have a variety of limitations and constraints, as previously discussed. A more detailed and refined future evaluation will be carried out during detailed design based on more specific information and adaptations to future needs of the population. There is significant room for optimisation related to the design that directly influences the total cost. A few of these options have been discussed in **Section 6.3: Value Engineering and Future Cost Reduction Considerations**.

Additional cost breakdown details can be found in **Appendix F.7.1: Excellent Fit Construction Cost Estimates** and **Appendix F.8: Parcel Impacts and Costs**.

Table 6-8 presents the estimated total costs for the Proposed Project over the lifetime of the project.

Table 6-8: Estimated Total Costs

	Proposed Project
Estimated Construction and Maintenance Cost CI$ Million (USD Million)	**$898.99** ($1,070.22)
Estimated ROW Cost CI$ Million (USD Million)	**$17.09** ($20.33)
Estimated Total Cost CI$ Million (USD Million)	**$916.08** ($1,090.55)

****Please note that all cost estimates provided are calculated in 2024 dollars, without adjustments for inflation. No inflation rates have been applied to account for future build years, and thus estimates reflect only current dollar values. US Dollars have been converted from CI Dollars at a rate of $0.84 CI = $1.00 US; $1.00 CI = $1.19 US.*

6.3 Value Engineering and Future Cost Reduction Considerations

This section examines various Value Engineering options that could be considered during the development of the Proposed Project. Value Engineering is a process focused on optimizing project value by identifying cost savings while maintaining the essential features and functionality of the project. The development of the Proposed Project involved balancing several factors, including engineering standards, local preferences, and environmental sustainability, as outlined in previous sections.

Throughout the design process, a conservative approach was adopted to prioritize safety and environmental sustainability, ensuring that the project meets the necessary standards. However, as with any large-scale engineering project, there is an inherent balance between performance and cost. For the Proposed Project, several options were explored to achieve cost savings while still adhering to design standards, safety requirements, and environmental protection goals, as well as incorporating local preferences.

The options explored in this section vary in terms of cost savings for both construction and maintenance, with each option offering its own pros and cons. More options can be investigated and added to the list during the detailed design phase of the project. The set of options presented herein serves as an initial toolbox for future decision-making and design refinement as the project advances to the detailed design phase. Options include modifications to materials, construction methods, design values (such as lane width), and design features (such as median barriers and structure types). Additionally, some options focus on potential changes to the typical sections.

As part of the Value Engineering process, two additional design scenarios were explored to demonstrate available options to the NRA for reducing the cost of the Proposed Project while nonetheless adhering to design standards, safety requirements, and environmental protection goals.

These alternatives, although introducing some trade-offs, still fulfil the established Critical Success Factors (CSFs).

The initial conceptual design, referred to throughout this ES, can be thought of as the "Excellent Fit" or the conceptual design option that optimally meets the CSFs and is the most resilient against storm events when compared to other Value Engineering options; however, also comes with the largest anticipated cost. Therefore, two more cost-effective conceptual design options could be considered:

1. **Good Fit**: This conceptual design variation is considered the next best option for storm resiliency. It achieves the CSFs at a reduced cost compared to the "Excellent Fit"; however will be less resilient to moderate storm events but still resilient to some storms such as mild storms and typical rainstorms that occur more frequently. More details are provided in **Section 6.3.1: Good Fit Design Option**.
2. **Acceptable Fit**: This option represents the most cost-effective solution but involves more significant trade-offs. While it is the least resilient to storms events when compared to the "Excellent Fit" and the "Good Fit" options, the "Acceptable Fit" option still meets all CSFs and remains a viable design solution. Its resiliency is focused on minor storm events and typical weather patterns, and although it may not perform as well during more severe storm conditions, this option does not compromise the overall functionality or success of the project. More details are provided in **Section 6.3.2: Acceptable Fit Design Option**.

Each of these design options offers a balanced approach to achieving project goals within different budgetary and storm resiliency levels.

6.3.1 Good Fit Design Option

The 25-year storm event approach, referred to as the "Good Fit", is an alternative to the currently assumed 50-year storm event, also known as the "Excellent Fit". This strategy lowers the roadway's design elevation to remain dry during a 25-year storm event, requiring less vertical elevation than the 50-year storm event. The 25-year storm event can be considered a more moderate storm than the 50-year event but is still more intense than a common storm. This approach would replace bridges with large box culverts to help lower roadway elevations. While this change offers several benefits, it also presents certain drawbacks that must be carefully evaluated. For more information about the Good Fit profile, refer to **Section 6.6.5.3: Good Fit Profile**.

6.3.1.1 Good Fit Design Criteria

The design criteria for the Good Fit option would remain consistent with those established for the Excellent Fit, as outlined in **Section 6.6: Design Criteria and Methodology**. However, the Good Fit option introduces additional considerations in hydraulic performance, specifically for the 25-year storm event, which will require further analysis during the detailed design phase. These refinements should focus on storm event performance, drainage strategy validation, and ensuring compliance with all regulatory and environmental requirements.

Future Hydraulic Modelling Needs:

- Expanded hydraulic modelling to assess storm surge effects, localized flooding risks, and drainage performance under varying storm intensities.
- Evaluation of large culverts instead of bridge structures to ensure capacity and resiliency under dynamic flow conditions.
- Integration of climate resiliency factors to enhance long-term performance and adaptability.
- Integration of new developments and potential drainage obstructions.

This additional analysis would need to support a robust and resilient drainage design, ensuring that the Good Fit option effectively manages hydraulic challenges while maintaining compliance with environmental standards.

6.3.1.2 Good Fit Typical Sections

The typical roadway sections for the Good Fit option remain largely consistent with those of the Excellent Fit, with a few key modifications. Bridges will be replaced with large box culverts, as the Good Fit option is conceptually designed for a lesser storm event. Additionally, the profile elevation has been adjusted to enhance resiliency to the 25-year storm event, resulting in lower fill slopes compared to the Excellent Fit option.

The utility corridors may need to be relocated outside the limits of the slopes if they cannot be accommodated over the box culverts. Placement of utilities and accommodations for potential conflicts with the drainage structures will need to be further refined during detailed design, particularly as utility needs are coordinated with local utility providers.

Utilities are further discussed in **Section 6.6.11: Utilities**.

6.3.1.3 Good Fit Cost Savings

The preliminary estimated total costs and potential savings for each build phase, compared to the Excellent Fit, utilising the 25-year storm event option, are detailed in **Table 6-9** below. This table not only outlines the financial aspects but also highlights the cost efficiencies achieved when compared to the 50-year storm event conceptual design. This analysis captures the effective application of Value Engineering principles, demonstrating how strategic design adjustments can significantly reduce project expenditures while upholding the integrity and functionality of the project.

Table 6-9: Good Fit 25-Year Storm Event Total Costs and Savings

		Total Construction and Maintenance Cost per Build-Year (CI$ Million)	Percent Cost Savings Compared to Proposed Project	Cost Savings (CI$ Million) Compared to Proposed Project	Total Estimated Construction and Maintenance Cost (CI$ Million)	Total Estimated Savings (CI$ Million) (1)
Good Fit 25-Year Design Storm w/Box Culverts Option	**2026 Totals:**	$194.58	~ 17%	$39.29	$749.02	$149.98
	2036 Totals:	$174.02	~ 30%	$74.43		
	2046 Totals:	$130.51	~ 17%	$26.26		
	2060 Totals:	$172.14	~ 6%	$11.17		
	2074 Totals:	$77.77	~ -1%	-$1.17		

** The costs presented in this table include the Will T Connector costs as part of the Good Fit alternative.*
*** Note that all cost estimates provided are calculated in 2024 dollars, without adjustments for inflation. No inflation rates have been applied to account for future build years, and thus estimates reflect only current dollar values. Estimated costs have been rounded where appropriate.*
**** Costs presented in this table include an additional contingency cost of 20% of the construction/maintenance costs.*
***** The costs presented reflect the concept design for the proposed project. It should be noted that all cost estimates are based on a conservative approach to the project's design and estimation process. Changes or optimizations made during detailed design stages will directly affect these costs.*
(1) Compared to the Excellent Fit Option

Further details regarding material quantity and costs can be found in **Appendix F.7.2: Good Fit Construction Cost Estimate**.

Right-of-Way Costs remain the same as that of the Excellent Fit and can be found in **Section 6.2.2: Right-of-Way (ROW) Cost Estimate**.

6.3.1.4 Benefits

- **Reduced Material Requirements:** Lowering the roadway profile reduces the volume of fill material needed and decreases the amount of excavation required for peat removal.
- **Structural Modifications:** The design can include large reinforced concrete box culverts as an alternative to the initially planned bridge structures. This change is feasible due to the lower stormwater elevations and the reduced roadway profile associated with the 25-year storm event.
- **Cost Advantages:** Adopting this design could reduce the overall project costs by 15% to 20%, as the use of large box culverts and reduced fill material aligns with the modified design specifications and offers cost savings.

6.3.1.5 Drawbacks

- **Increased Vulnerability to Larger Storms:** Designing for a 25-year storm event means the infrastructure may not withstand the effects of more severe storms, potentially leading to increased flooding and damage to the roadway.
- **Maintenance and Repair Costs:** With a design that is less robust against severe weather, there may be a higher frequency of maintenance and repair activities required to address wear and tear or storm damage.

- **Potential Safety Risks:** Lower freeboard and closer proximity to design limits during major storms could pose safety risks to roadway users, particularly during unexpected or unusually severe weather events.

The Corridor Roll Maps, included in **Appendix F.1.1: Excellent Fit Corridor Roll Maps**, present a conceptual profile line for the 25-year storm event. A conceptual comparison analysis was conducted to assess the technical and financial implications of adopting a 25-year storm event standard, as opposed to the currently assumed 50-year storm event. This analysis involved:

- **Reassessing Material Requirements:** Evaluating the necessary adjustments in the quantity of fill material and excavation needed due to the lowered roadway profile.
  Cost Savings Analysis: Estimating the potential cost savings achieved by utilising box culverts instead of bridges, alongside reductions in construction materials.
- **Long-Term Maintenance Assessment:** Analysing the long-term maintenance requirements and associated costs for both the 25-year and 50-year storm event scenarios to determine the most cost-effective and sustainable option.

6.3.2 Acceptable Fit Design Option

Another alternative approach considered, referred to as the "Acceptable Fit" involves further lowering the roadway profile beyond the "Good Fit" level. To achieve this even lower roadway profile, the large culvert structures would be replaced with smaller, more frequently placed box culverts or pipes.

6.3.2.1 Acceptable Fit Design Criteria

The design criteria for the Acceptable Fit remains the same as that of the Excellent Fit, which is further discussed in **Section 6.6: Design Criteria and Methodology**. The Acceptable Fit option will require additional hydraulic analysis and modelling to fully assess its performance during storm events in the detailed design phase. This future work should detail the effects of storms on this drainage strategy, ensuring all regulatory and environmental standards are upheld.

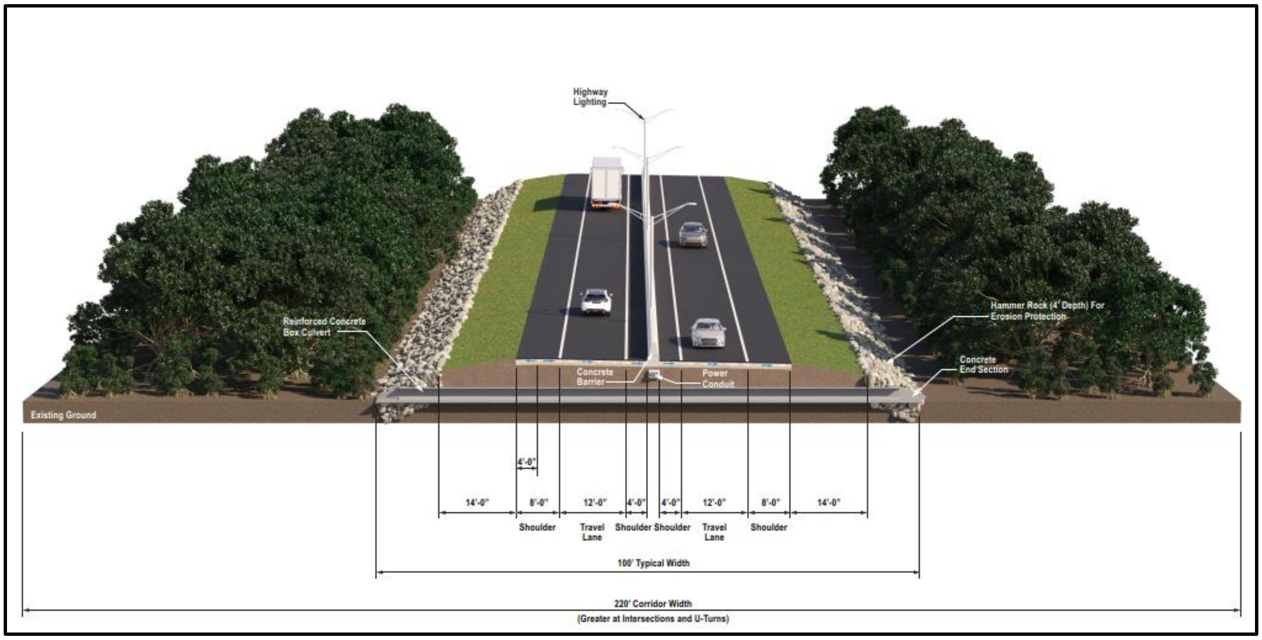
<u>Future Hydraulic Modelling Needs:</u>

- Comprehensive hydraulic modelling to simulate storm surge and rainfall impacts.
- Validation of culvert design under dynamic flow conditions to confirm adequacy and resiliency.

6.3.2.2 Acceptable Fit Typical Roadway Sections

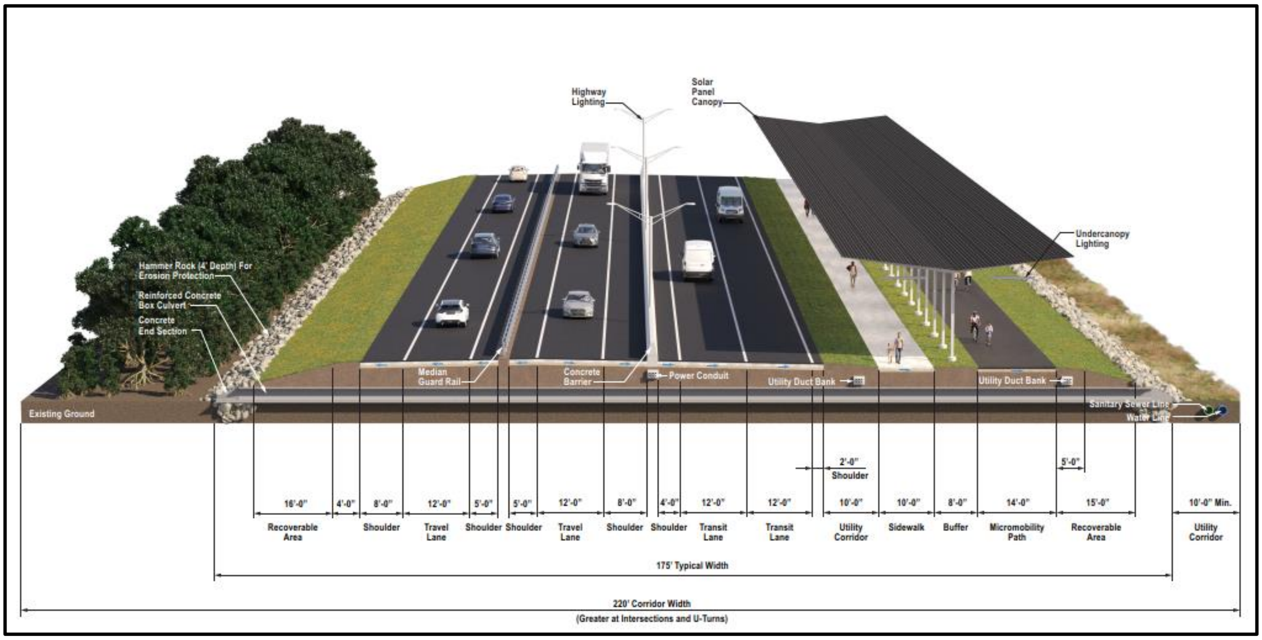
The typical roadway sections for the Acceptable Fit remain mostly the same as that of the Excellent Fit, with a few notable changes. The larger pipe culverts have been replaced with the proposed smaller, box culverts. The height of the fill slopes is lower due to the adjustment to profile elevation. The utility corridors have been relocated to just outside the limits of the slopes, due to the additional available space. Placement of utilities and accommodations for potential conflicts with the drainage structures will need to be determined in detailed design and as utility needs are identified with local providers. Utilities are further discussed in **Section 6.6.11: Utilities**.

Figure 6-8: Year 2026 – Typical Sections – Acceptable Fit

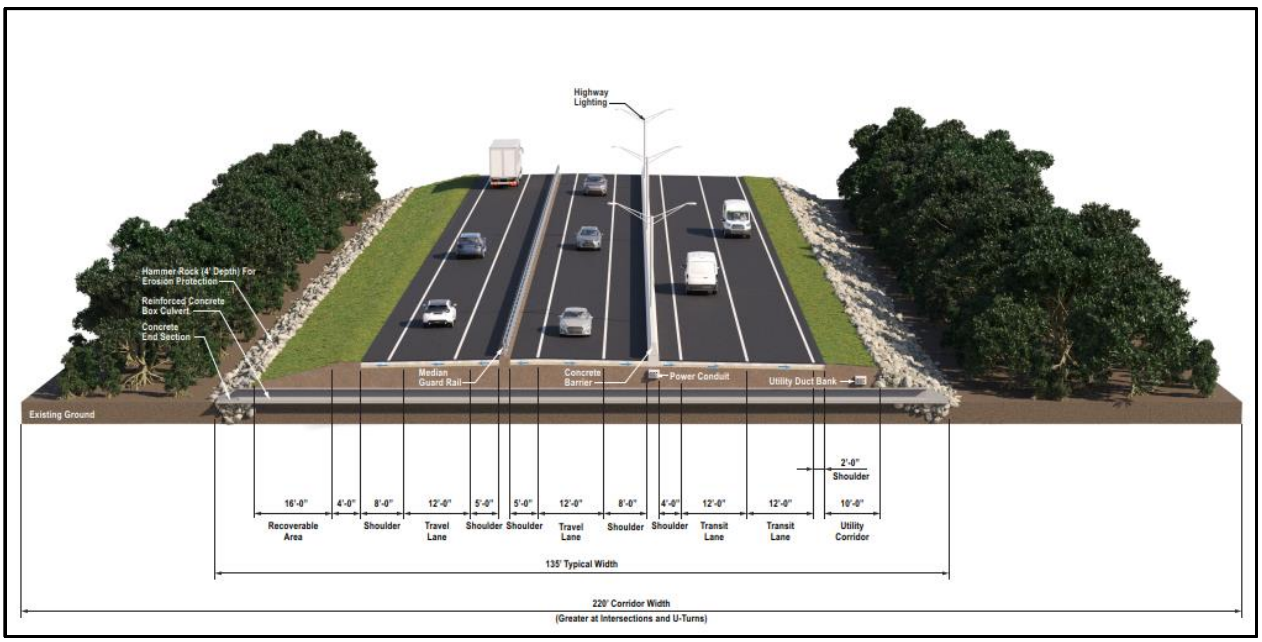


Acceptable Fit – Sections 2 and 3 (Woodland Drive to Frank Sound Road)
Includes two travel lanes (one in each direction), shoulders, median barrier, and highway lighting.

Figure 6-9: Year 2036 – Typical Sections – Acceptable Fit

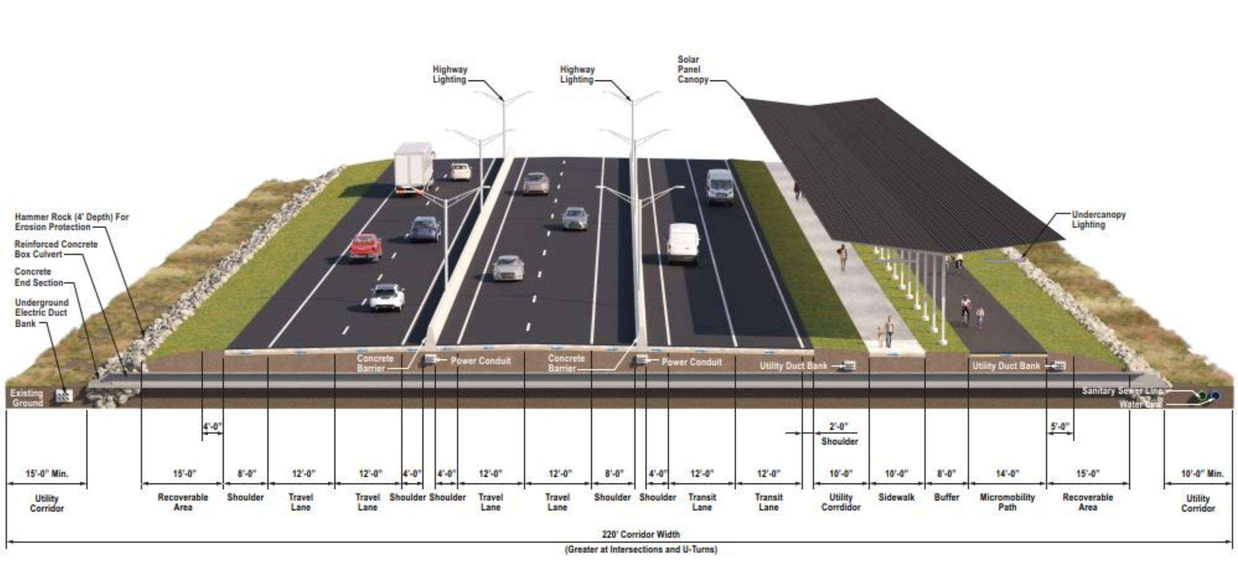


Acceptable Fit – Section 2 (Woodland Drive to Lookout Road)
Acceptable Fit – Section 3 (Lookout Road to Frank Sound Road as Needed)
Includes two travel lanes (one in each direction), shoulders, median barrier, highway lighting, transit lanes, sidewalk, micromobility path, solar array, and utility corridors.

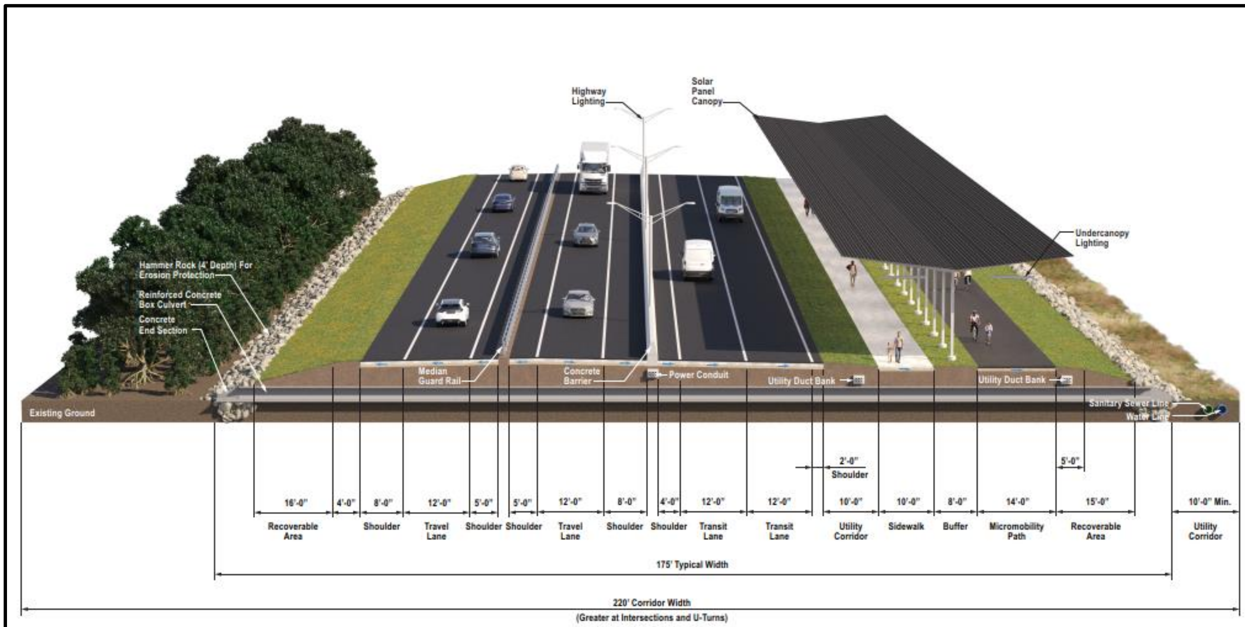


Acceptable Fit – Section 3 (Lookout Road to Frank Sound Road)
Includes two travel lanes (one in each direction), shoulders, median barrier, highway lighting, transit lanes, and a utility corridor.

Figure 6-10: Year 2046 – Typical Sections – Acceptable Fit

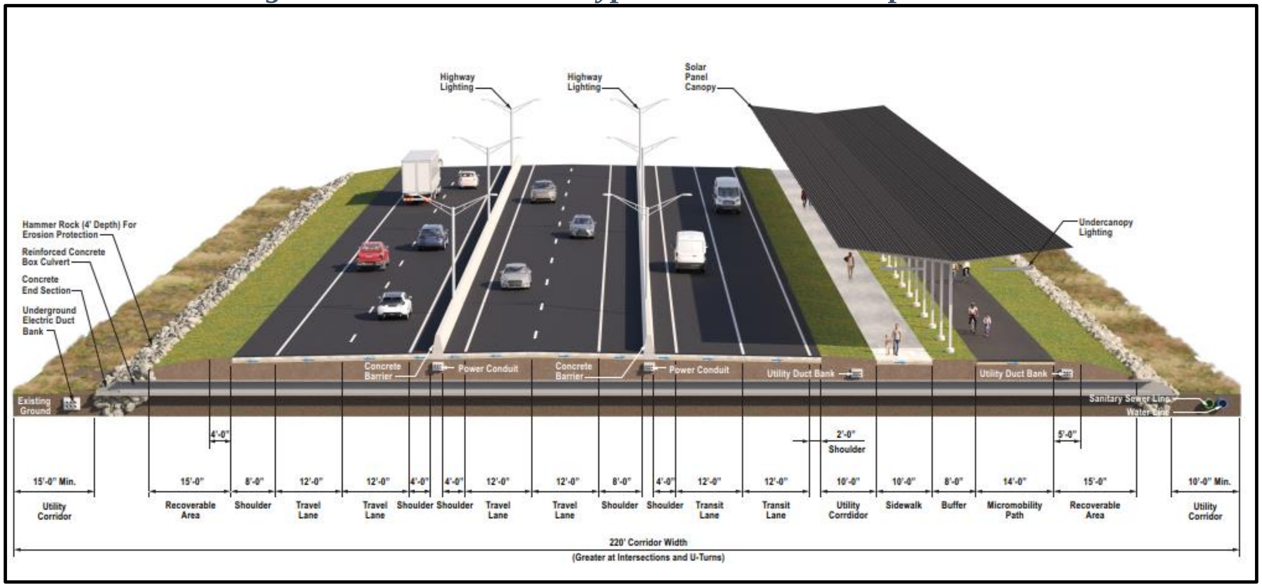


Acceptable Fit – Section 2 (Woodland Drive to Lookout Road)
Includes four travel lanes (two in each direction), shoulders, median barrier, highway lighting, transit lanes, sidewalk, micromobility path, solar array, and utility corridors.



Acceptable Fit – Section 3 (Lookout Road to Frank Sound Road)
Includes two travel lanes (one in each direction), shoulders, median barrier, highway lighting, transit lanes, sidewalk, micromobility path, solar array, and utility corridors.

Figure 6-11: Year 2060 – Typical Sections – Acceptable Fit



Acceptable Fit – Sections 2 and 3 (Woodland Drive to Frank Sound Road)
Includes four travel lanes (two in each direction), shoulders, median barrier, highway lighting, transit lanes, sidewalk, micromobility path, solar array, and utility corridors.

Larger versions of the Acceptable Fit Typical Sections can be found in **Appendix F.3.2: Acceptable Fit Typical Sections**.

6.3.2.3 Acceptable Fit Cost Breakdown and Savings

The Acceptable Fit criteria were applied to the design of the Proposed Project, following the same methodology used for the Good Fit and Excellent Fit options. Material quantities and total costs for both new construction and lifecycle maintenance (e.g., milling, resurfacing, drainage repairs etc.) were evaluated accordingly.

A conceptual cost breakdown for Section 2 and Section 3 of the Acceptable Fit option is provided in **Table 6-10**, segmented by Build-Year Phase and corresponding estimated construction years. This table includes a distinct breakdown of estimated costs for both primary roadway features and optional features.

<u>Primary Roadway Features included</u>:

- New construction costs
- Lifecycle maintenance costs (e.g., milling and resurfacing)

<u>Optional Features included</u>:

- Micromobility path
- Sidewalk
- Transit lanes
- Will T Connector in Section 2

With the separately itemized optional features, future lifecycle maintenance costs are shaded in grey to clearly differentiate them from new build costs. This shading applies only to optional features, highlighting their long-term maintenance implications in later years.

The total cost presented in this breakdown represents the sum of new construction costs, lifecycle maintenance costs, and optional features over a 50-year period. It is important to note that the total cost is not simply the cost to build the corridor; rather, it reflects the full investment required to construct and maintain the corridor over its lifecycle.

The cost to build the corridor—meaning the initial construction costs—is represented by the values in the new construction cost columns for Section 2 and Section 3, broken down by year. This accounts for the infrastructure necessary to establish the roadway itself. The lifecycle maintenance costs account for periodic resurfacing and other long-term upkeep, while optional features reflect additional enhancements that may be implemented based on funding availability and project priorities.

This approach provides a comprehensive financial outlook, allowing for informed decision-making on both the initial capital investment and the long-term sustainability of the corridor.

Similar to the cost breakdown in **Section 6.2.1: Construction Cost**, this table presents a preliminary estimation approach, accounting for varying production rates across different construction activities. However, it should not be interpreted as a construction schedule, as detailed scheduling will be determined during the final design phase if this option is pursued.

This conceptual cost breakdown serves to:

- Clarify cost allocations for both initial construction and long-term maintenance.
- Provide insight into the financial implications of core project elements and optional features.
- Support informed decision-making by distinguishing required and discretionary investments.

Table 6-10: Estimated Construction and Maintenance Costs for the Acceptable Fit by Build-Year and Section (CI$ Million)

Build-Year Phase	Construction Year	Section 2						Section 3				
		Primary Roadway Features		Optional Features				Primary Roadway Features		Optional Features		
		Travel Way Construction Cost by Year (CI$)	Travel Way Maintenance Cost by Year (CI$)	Micomobility Path Cost by Year (CI$)	Sidewalk Cost by Year (CI$)	Transit Lanes Cost by Year (CI$)	Will T Connector Cost by Year (CI$)	Travel Way Construction Cost by Year (CI$)	Travel Way Maintenance Cost by Year (CI$)	Micomobility Path Cost by Year (CI$)	Sidewalk Cost by Year (CI$)	Transit Lanes Cost by Year (CI$)
2026	**2026**	$12.06	-	-	-	-	-	-	-	-	-	-
	2027	$18.05	-	-	-	-	-	-	-	-	-	-
	2028	-	-	-	-	-	-	$13.72	-	-	-	-
	2029	-	-	-	-	-	-	$9.37	-	-	-	-
	2030	-	-	-	-	-	$10.83	$29.37	-	-	-	-
Build-Year Subtotal:		**$30.11**	-	-	-	-	**$10.83**	**$52.46**	-	-	-	-
2036	**2036**	-	-	$2.16	$1.22	$5.18	-	-	-	-	-	-
	2037	-	$13.31	$1.70	$5.24	$12.89	-	-	-	-	-	-
	2038	-	-	-	-	-	-	-	-	$1.97	$1.07	$10.44
	2039	-	-	-	-	-	$4.02	-	$17.71	$0.65	$1.43	$17.84
Build-Year Subtotal:		-	**$13.31**	**$3.86**	**$6.46**	**$18.07**	**$4.02**	-	**$17.71**	**$2.62**	**$2.50**	**$28.28**
2046	**2046**	$8.28	$3.20	-	-	-	-	-	-	-	-	-
	2047	$6.42	$4.59	$1.57	-	$5.18	-	-	-	-	-	-
	2048	-	-	-	-	-	-	-	$18.85	5.82	4.35	-
	2049	-	-	-	-	-	$4.49	-	$8.27	$2.85	$6.94	$8.50
Build-Year Subtotal:		**$14.70**	**$7.79**	**$1.57**	-	**$5.18**	**$4.49**	-	**$27.12**	**$8.67**	**$11.29**	**$8.50**
2060	**2060**	$11.10	$15.56	$1.12	$11.18	$9.94	-	-	-	-	-	-
	2061	-	-	-	-	-	-	$13.39	-	-	-	-
	2062	-	-	-	-	-	$4.02	$24.86	$20.91	$2.68	$2.72	$12.25
Build-Year Subtotal:		**$11.10**	**$15.56**	**$1.12**	**$11.18**	**$9.94**	**$4.02**	**$38.25**	**$20.91**	**$2.68**	**$2.72**	**$12.25**
2074	**2074**	-	$14.81	$1.50	-	$4.44	$11.80	-	-	-	-	-
	2075	-	-	-	-	-	-	-	$16.24	$3.57	$14.43	$6.52
Build-Year Subtotal:		-	**$14.81**	**$1.50**	-	**$4.44**	**$11.80**	-	**$16.24**	**$3.57**	**$14.43**	**$6.52**
Section Total:		**$55.91**	**$51.47**	**$8.05**	**$17.64**	**$37.63**	**$35.16**	**$90.71**	**$81.98**	**$17.54**	**$30.94**	**$55.55**
		Section 2 Total Construction and Maintenance Cost = $205.86						**Section 3 Total Construction and Maintenance Cost = $276.72**				
Total Construction and Maintenance Cost for the Proposed Project = $482.58												

** Note that all cost estimates provided are calculated in 2024 dollars, without adjustments for inflation. No inflation rates have been applied to account for future build years, and thus estimates reflect only current dollar values. Estimated costs have been rounded where appropriate.*
*** The costs presented reflect the concept design for the proposed project. It should be noted that all cost estimates are based on a conservative approach to the project's design and estimation process. Changes or optimizations made during detailed design stages will directly affect these costs.*
**** Costs presented in this table include an additional contingency cost of 20% of the construction/maintenance costs as well as an additional cost for Potential Terrestrial Ecology Mitigation.*
***** Yellow highlighted values for the optional features indicate that the cost is purely maintenance related.*

In addition, the estimated cost savings of the Acceptable Fit option compared to the Excellent Fit can be seen in **Table 6-11** below.

Table 6-11: Acceptable Fit Total Costs and Savings

		Total Construction and Maintenance Cost per Build-Year (CI$ Million)*	Percent Cost Savings Compared to Proposed Project	Cost Savings (CI$ Million) Compared to Proposed Project	Total Estimated Construction And Maintenance Cost (CI$ Million)*	Total Estimated Savings (CI$ Million) (1)
Acceptable Fit Design w/Box Culverts/Pipes Option	2026 Totals:	$82.57	~ 65%	$151.29	$477.42	$451.57
	2036 Totals:	$92.81	~ 63%	$155.63		
	2046 Totals:	$84.82	~ 46%	$71.95		
	2060 Totals:	$125.71	~ 31%	$57.61		
	2074 Totals:	$61.51	~ 20%	$15.08		

** The costs presented in this table exclude the Will T Connector costs as it can be considered as an optional, future consideration as part of the Acceptable Fit based on demand and funding.*
*** Note that all cost estimates provided are calculated in 2024 dollars, without adjustments for inflation. No inflation rates have been applied to account for future build years, and thus estimates reflect only current dollar values. Estimated costs have been rounded where appropriate.*
**** Costs presented in this table include an additional contingency cost of 20% of the construction/maintenance costs as well as an additional cost for Potential Terrestrial Ecology Mitigation.*
***** The costs presented reflect the concept design for the proposed project. It should be noted that all cost estimates are based on a conservative approach to the project's design and estimation process. Changes or optimizations made during detailed design stages will directly affect these costs.*
(1) Compared to the Excellent Fit Option

Further details regarding material quantity and costs can be found in **Appendix F.7.3: Acceptable Fit Construction Cost Estimate**.

Right-of-Way Costs remain the same as that of the Excellent Fit and can be found in **Section 6.2.2: Right-of-Way (ROW) Cost Estimate**.

6.3.2.4 Benefits

- **Reduced Material Requirements:** Lowering the roadway profile decreases both the volume of fill material needed and the extent of excavation required for peat removal.
- **Elimination of Large Structures:** The design eliminates the need for planned bridge structures or large box culverts. Instead, smaller reinforced concrete box culverts or pipes are strategically placed along the corridor to maintain local hydrologic connectivity. This

approach is feasible since the lower roadway would be designed for a less severe storm event.

- **Cost Advantages:** Implementing this design could reduce the overall project costs by 40% to 60%, as replacing large structures with smaller, more frequent culverts along with reduced fill materials, aligns with the modified design specifications and provides significant cost benefits (refer to **Table 6-11** above).
- **Faster Construction Timeline:** Reducing the roadway profile and eliminating larger structures can streamline construction, leading to shorter project schedules and minimizing traffic disruptions.
- **Minimized Environmental Impact:** A lower roadway profile and reduced material requirements may decrease environmental disturbance, particularly in sensitive areas such as wetlands.
- **Improved Constructability:** Simplified design elements (e.g., replacing bridges with smaller culverts) may reduce construction complexity, requiring fewer specialized materials and labour.

6.3.2.5 Drawbacks

- **Increased Vulnerability to Severe Storms:** Designing for a lesser storm event may reduce resiliency against more extreme weather conditions, increasing the risk of flooding and roadway damage, when compared to the Excellent and Good Fit options.
- **Higher Maintenance and Repair Costs:** A less robust design may lead to more frequent maintenance and repair needs due to wear, erosion, or storm-related damage.
- **Potential for Increased Road Closures:** More frequent maintenance or repairs due to storm impacts could lead to periodic road closures, affecting traffic flow and accessibility.
- **Potential Safety Risks:** Operating closer to design limits during major storms could pose safety concerns for roadway users, particularly during unexpected or exceptionally severe weather events.

6.3.3 Design Option Critical Success Factor (CSF) Comparison

The Excellent Fit, Good Fit, and Acceptable Fit design options perform similarly in addressing the CSFs as outlined in **Table 6-1**. The primary distinction lies in the Roadway Resiliency factor.

The Excellent Fit achieves the highest resiliency, featuring a higher corridor elevation and design standards accommodating a 50-year storm event. The Good Fit maintains resiliency for a 25-year storm event — providing a moderate level of resiliency, though not as robust as the Excellent Fit. The Acceptable Fit offers the least resiliency of the three options, yet still performs adequately under lesser storm conditions due to the corridor still being elevated.

Importantly, all three options offer an alternative east-west route across the island and demonstrate a shared level of resiliency in maintaining network connectivity. A qualitative comparison of how each option meets the CSFs is presented in **Table 6-12** below. The darkest shade of green signifies the criteria is optimally met, while the lighter the shade of green, the lesser the degree to which the criteria are met.

Table 6-12: Design Options - Critical Success Factors Comparison

Critical Success Factor	No Build	Excellent Fit	Good Fit	Acceptable Fit
Alternative Routes	-	✓	✓	✓
Roadway Resiliency	-	✓	✓	✓
Future Traffic Demand	-	✓	✓	✓
Commuter Travel Time	-	✓	✓	✓
Utilities	-	✓	✓	✓
Public Transit Access	-	✓	✓	✓
Tourist Travel Times	-	✓	✓	✓
Safety	-	✓	✓	✓
Pedestrian and Bicycle Access	-	✓	✓	✓

6.3.4 Additional Value Engineering Options

In addition to the Good Fit and Acceptable Fit approaches to cost reduction, several independent cost-saving options can be applied to the Proposed Project and its alternative approaches. Many of these options can be implemented simultaneously, with some requiring no additional design work or information. Others, however, may require further investigation, additional design, or data collection before implementation.

Table 6-13 outlines these additional Value Engineering options; their applicability to each alternative approach; and approximate magnitude of potential cost savings**.** More details, including the pros and cons for each option can be found in **Appendix F.10: Value Engineering Options**.

Table 6-13: Summary of Cost Reduction Options

Option Description	Potential Cost Savings in 2026 (Percentage)	Potential Cost Savings in 2026 (CI$ Million)	Potential Cost Savings by 2074 (Percentage)	Potential Cost Savings by 2074 (CI$ Million)
Elevate Only 2 Travel Lanes for Resiliency*	High – 40% to 60%	$93.55 to $140.32	High – 40% to 60%	$359.59 to $539.39
Elevate Only 4 Travel Lanes for Resiliency*	None	$0.00	Medium to High – 10% to 40%	$89.90 to $359.59
Elevate Only 2 Travel Lanes – Employ ITS Options*	None	$0.00	High – 40% to 60%	$359.59 to $539.39
Use of Alternative Structure Type (Box Culvert)*	Medium – 5% to 10%	$11.69 to $23.39	Medium – 10% to 15%	$89.90 to $134.85
Use of Viaduct Sections**	None (Substantial Increase)	$0.00	None (Substantial Increase)	$0.00
Reduce Structure Height*	Medium – 5% to 10%	$11.69 to $23.39	Low to Medium – 1% to 5%	$8.99 to $44.95
Reduce Fill Slope Grade to 4:1	Low to Medium – 1% to 5%	$2.34 to $11.69	Low – Less than 1%	$8.99
Reduce Fill Slope Grade to 3:1	Low to Medium – 1% to 5%	$2.34 to $11.69	Low – Less than 1%	$8.99
Reduce Fill Slope Grade to 2.5:1	Low to Medium – 1% to 5%	$2.34 to $11.69	Low – Less than 1%	$8.99
Reduce Fill Slope Grade to 2:1	Medium – 5% to 10%	$11.69 to $23.39	Low – Less than 1%	$8.99
Use of Geosynthetic Solutions to Address Peat Area* ^ ~	Low to Medium – 1% to 5%	$2.34 to $11.69	Low to Medium – 1% to 5%	$8.99 to $44.95
Reduction of Travel Lane Width from 12 ft to 11 ft ^ ~	Low to Medium – 1% to 5%	$2.34 to $11.69	Low to Medium – 1% to 5%	$8.99 to $44.95
Change Concrete Median Barrier to Guard Rail System ^ ~	Low to Medium – 1% to 5%	$2.34 to $11.69	Low to Medium – 1% to 5%	$8.99 to $44.95

Option Description	Potential Cost Savings in 2026 (Percentage)	Potential Cost Savings in 2026 (CI$ Million)	Potential Cost Savings by 2074 (Percentage)	Potential Cost Savings by 2074 (CI$ Million)
Change 8 ft Paved Shoulder to 2 ft Paved and 6 ft Graded Aggregate ^ ~	Low – Less than 1%	$2.34	Low to Medium – 1% to 5%	$8.99 to $44.95
Reduce Width of Sidewalk and Micromobility Path^ ~	Medium – 5% to 10%	$11.69 to $23.39	Low to Medium – 1% to 5%	$8.99 to $44.95
Locate Utilities Below Micromobility Path^	Low – Less than 1%	$2.34	Low – Less than 1%	$8.99

^Option can be applied to the "Good Fit" alternative with a greater percentage of savings than that of the "Excellent Fit".
~Option can be applied to the "Acceptable Fit" alternative with a greater percentage of savings than that of the "Excellent Fit" or "Good Fit".
**Indicates that option would require additional information gathering and/or further design work*
*** Potential savings may be found through reduced environmental impact; further investigation is required.*
Estimated costs have been rounded where appropriate.

6.4 Design Limitations

The Proposed Project extends and refines the Alternative B3 design from the Shortlist Alternatives Evaluation, building upon its methodology while addressing specific design limitations inherent at this conceptual stage. As is typical with early-stage design, limitations exist due to factors such as: the availability and precision of site-specific data, the type and level of analysis that is not feasible at this stage based on limited available data and need for further design development in adjacent disciplines, the coordination of development of the project with other governmental departments and statutory authorities, and the ongoing need to align project elements with both NRA's preferences and potential future development modifications.

Many aspects of the project design rely on available information regarding the existing conditions of the project site. Accurately designing a facility for a specific location generally requires a detailed survey that captures existing features such as vegetation, structures, water bodies, topography, and other geographic characteristics. However, due to the remoteness of the site, comprehensive site-specific ground surveys were not feasible at this stage. Instead, much of the available data—including ground elevation—was obtained via LiDAR (Light Detection and Ranging), an aerial survey method using laser-based technology. While effective, LiDAR lacks the precision of on-site data collection, affecting design accuracy. For example, existing elevations may differ from expectations, which could impact the volume of embankment or fill materials required to achieve intended roadway elevations. This limitation extends to other project elements, such as alignment, profiles, environmental impact assessments, and drainage.

Additional limitations stem from the concise analysis required at this stage. For instance, detailed drainage design—such as finalizing the location and sizing of inlets and pipes—depends on comprehensive data about topography, soil composition, vegetation, and precipitation patterns as well as the results obtained from a refined hydrological model that would use the updated data. Therefore, as design advances, detailed survey information will be critical for refining the drainage system. For further information, see **Section 6.6.6: Drainage, Stormwater, and Hydraulic Management**. Similarly, limited geological data impacts excavation planning for foundations and roadway embankments. While spot data on rock, soil, and peat depths has been used, a full geotechnical investigation is essential to support detailed embankment and foundation design. Refer to **Section 6.8.2: Constructability Considerations** for more on the application of peat data in design considerations.

Hydrologic and hydraulic assessments, integral to determining bridge and profile elevations, were guided by preliminary studies from Baird and RVE. Their reports analysed storm and rainfall events affecting the study area and proposed initial hydrology-based design elevations. As these assessments were based on preliminary findings, further refinement will be necessary in future design stages to validate bridge locations and openings. For additional discussion, refer to **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** and **Appendices J.1 through J.8**. Further details on the integration of preliminary hydrology with profile and bridge elevations are available in **Section 6.6.5: Vertical Grades, Cross Slopes, and Roadway Profiles** and **Section 6.6.7: Hydraulic Structures**.

Additionally, coordination between governmental departments and statutory authorities is another potential design limitation for the development of the project. In general, different departments and authorities in Grand Cayman have different functions and oversights. There are aspects of the project that may involve different entities that have influence over those aspects, but in different ways. A difference of opinion on approach or vision, allocation of that entity's resources elsewhere, and the level of communication between the two entities may influence whichever is responsible to act. This may prove to be an obstacle to achieve the goals of the proposed project.

Finally, project design decisions influenced by NRA's preferences and potential future modifications present additional limitations. For example, initial assumptions regarding multimodal elements, such as sidewalk widths and bus stop locations, may require revision if usage patterns change. Budgetary constraints could also affect the feasibility of certain design features, necessitating further adjustments. As the design progresses, these elements will be refined to ensure alignment with both NRA's needs and project objectives. For additional details on cost-saving strategies and alternate considerations, refer to **Section 6.3: Value Engineering and Future Cost Reduction Considerations** and **Appendix F.10: Value Engineering Options**.

In summary, the Proposed Project has been developed to a conceptual level appropriate for an EIA, based on the current information available. Advancing the design will require more precise data, continued alignment with evolving site conditions, and adjustments to accommodate NRA's preferences. These limitations, as highlighted, indicate the need for ongoing refinement and design updates as additional information becomes available in subsequent stages.

6.5 Proposed Project Refinements

As additional information was collected, a number of design refinements were made for the Proposed Project when compared to the original Shortlisted Build Alternative B3. These changes were driven by NRA preferences, striving to best avoid and minimise environmental impacts, and the natural progression of design information. The following describes these refinements, which will be discussed in more detail within subsequent sections of this chapter.

6.5.1 Typical Section Modifications

The typical section underwent several key changes including a revision of the build year sequence phasing that moved up the construction of dedicated transit lanes from year 2046 to 2036. This change was made to enhance pedestrian and micromobility access to transit infrastructure earlier in the project timeline and make it easier for pedestrians to access the facilities. In the original design, pedestrians would have needed to cross active traffic lanes to reach these facilities. Eliminating these crossings and shortening the distances pedestrians need to travel in order to reach the transit stop should enhance both access and safety for all road users. However, this modification requires a shifting of traffic lanes in 2036, 2046 and again in 2060, requiring an additional median to be constructed that would then need to be removed in the final configuration.

In addition, the roadway's profile grade point, or crown point, was shifted to align more centrally with the ultimate build-out section. This adjustment would provide a more balanced distribution of stormwater runoff across the typical section and allows for a slightly lower vertical profile, thereby minimising the overall disturbance footprint for the roadway. To further minimise the disturbance footprint of the roadway, the cut and fill slopes were refined to tie into the existing ground terrain more quickly, while maintaining safe, traversable slopes and reserving space for dedicated utility corridors.

6.5.2 Intersection Modifications

The suggested intersection locations and configurations were also refined. As part of the Shortlist Alternatives Evaluation stage, roundabout designs were assumed to provide full access intersection movements at each of the seven proposed intersection locations, including two at the Proposed Project's western and eastern termini. However, as a result of further examining access needs and ways to reduce disturbance area, only two roundabouts are included along the Proposed Project corridor, at the project's western and eastern termini. One additional full access intersection is included at Lookout Road, where the corridor transitions between Section 2 and Section 3, with all remaining intersections being of partial access configuration. As a result of these intersection changes, when comparing the initial 2026 build year to the ultimate 2060 build year, the 2026 build utilises approximately 40-50% of the corridor footprint compared to that of 2060.

6.5.3 Bridge Structure Adjustments

The proposed bridge structure locations were also modified as a result of changes to the typical section and intersection configurations. These adjustments were made so that the structures align with the revised intersection geometries, as well as any tapers or cross-slope transitions necessary for the project's typical section. In most cases, the bridges were shifted several hundred feet east or west, although some retained their original locations from the Shortlist Alternatives Evaluation. These adjustments were made with consideration that the ultimate location of the structures will be defined based on refined hydraulic modelling, which will determine the optimal positions for and sizing of these structures. Therefore, the most appropriate solution will be implemented as part of detailed design.

6.5.4 Profile Revisions

In conjunction with the changes to structure locations and typical section, the Proposed Project profile was slightly modified. These adjustments allow the bridge elevations to continue to meet established design criteria while maintaining compliance with roadway profile standards across the corridor. In accordance with the conceptual design, the current vertical profile of the road is based on the 50-year storm event and is a conservative approach. This elevation was chosen to aid in considering potential changes due to sea-level rise and to assist in accounting for unpredictable variables in the storm event modelling. Additionally, the use of this elevation pre-emptively provides for potential challenges that may be necessary related to unknown ground conditions and other structure clearance needs. These revisions were applied to the concept level design with further optimization to occur during the detailed design stage to provide for a best fit, cost-effective solution.

6.6 Design Criteria and Methodology

6.6.1 Design Criteria

The design criteria guiding the development of the Proposed Project is presented in **Table 6-14**. These criteria were developed using various design guidelines and references that will continue to serve as a foundation during detailed design, including:

- American Association of State Highway and Transportation Officials (AASHTO) Geometric Design of Highways and Streets (Green Book 2018 – 7^{th} Edition)
- AASHTO Guide for the Development of Bicycle Facilities (2012)
- AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities (2004)
- AASHTO Roadside Design Guide (2011)
- Florida Department of Transportation (FDOT) Standard Plans for Road Construction (2024-25)
- National Association of City Transportation Officials (NACTO) Urban Bikeway Design Guide (2011)
- Traffic Signs Manual – Guidance for Traffic Authorities on the Use of Traffic Signs and Road Markings (UK Department for Transport, June 2006, including updates)

Table 6-14: Engineering Design Criteria

Criteria		Required Value	Proposed Value	Source Of Criteria
Design Vehicle		WB-50 Wheelbase 50-ft (15.2 m)	WB-50 Wheelbase 50-ft (15.2 m)	NRA Guidance
Design Speed		50 to 75 mph (80-120 km/h)	50 mph (80 km/h)	AASHTO Greenbook (2018) Section 7.2.2.1
Lane Width		11 ft (3.3 m) to 12 ft (3.6 m)	12 ft (3.6 m)	AASHTO Greenbook (2018) Table 7-3
Shoulder Width (Outside)		8 ft (2.4 m) to 10 ft (3.1 m) – Travel Lanes 2 ft (0.6 m) – Transit Lanes	8 ft (2.4 m) – Travel Lanes 2 ft (0.6 m) – Transit Lanes	AASHTO Greenbook (2018) Table 7-3 & Section 7.2.11.4
Shoulder Width (Inside)		4 ft (1.2 m)	4 ft (1.2 m)	
Clear Zone Width		22 ft (6.7 m) – Travel Lanes 12 ft (3.7 m – Transit Lanes	22 ft (6.7 m) – Travel Lanes 12 ft (3.7 m) – Transit Lanes	AASHTO Roadside Design Guide (2011) Table 3-1
Minimum Horizontal Radius		833 ft (253.9 m)	2389 ft (701 m)	AASHTO Greenbook (2018) Table 3-7
Maximum Superelevation Rate		4%	4%	AASHTO Greenbook (2018) Section 7.2.2.8 NRA Guidance
Vertical Grade	Minimum	0.3%	0.3%	AASHTO Greenbook (2018) Table 7-2
	Maximum	4%	3%	
Vertical Curve Minimum K Value	Crest Curve	84	84	AASHTO Greenbook (2018) Table 3-35
	Sag Curve	96	96	AASHTO Greenbook (2018) Table 3-37
Minimum Stopping Sight Distance		425 ft (129.5 m)	425 ft (129.5 m)	AASHTO Greenbook (2018) Table 7-1
Minimum Intersection Sight Distance		555 ft (169.1 m)	555 ft (169.1 m)	AASHTO Greenbook (2018) Table 9-7
Minimum Cross Slope		2%	2.5%	AASHTO Greenbook (2018) Section 7.2.2.7
Minimum Vertical Clearance	Highway	16.5 ft (5 m)	16.5 ft (5 m)	AASHTO Greenbook (2018) Section 7.2.5.1
	Waterway	3 ft (1 m) Drift Clearance Above 50 yr. Storm Event	3 ft (1 m) Drift Clearance Above 50 yr. Storm Event	NRA Guidance
	Pedestrian	10 ft (3.1 m)	10 ft (3.1 m)	AASHTO Bike Guide (2012) Section 5.2.10
Minimum Sidewalk Width		5 ft (1.5 m)	10 ft (3.1 m)	AASHTO Pedestrian Guide (2004) Section 3.2.3
Multi-Use Path Width		10 ft (3.1 m)– 14 ft (4.2 m)	14 ft (4.2 m)	AASHTO Bike Guide (2012) Section 5.2.1
Multi-Use Path Cross Slope		1.5% Max	1.5% Max	AASHTO Bike Guide (2012) Section 5.2.5

In addition to AASHTO and NACTO guidelines, local input from the NRA was utilised in defining specific design elements, such as superelevation rates and minimum waterway clearances to accommodate maintenance activities. These criteria established the framework for designing the roadway's geometric, functional, and safety features. The Cayman Islands classifies roadway facilities as either Primary or Secondary Arterial roadways and the Proposed Project would be classified as a Primary Arterial. For design purposes, the AASHTO classification of Rural Principal Arterial was used to establish appropriate design criteria as summarized in **Table 6-14** above.

The following sections Functional Classification and Design Speed and Horizontal Alignment Considerations serve complementary purposes. Functional Classification and Design Speed explains how the design speed was selected based on the roadway's role as a Primary Arterial (Rural Principal Arterial per AASHTO), supporting safe and efficient travel.

Horizontal Alignment Considerations focuses on translating this design speed into specific roadway features, like curve radii and superelevation, while accounting for environmental and geographic constraints to ensure safety and environmental sensitivity.

6.6.2 Functional Classification and Design Speed

The Proposed Project is classified as a Primary Arterial (Rural Principal Arterial per AASHTO) with level topography. Based on this functional class, projected traffic volumes, and the corridor's role as a main island thoroughfare, a design speed of 50 mph (80 km/h) was selected. This design speed was chosen to provide continuity with the existing roadway, optimize travel routes, and accommodate the geometric conditions of the study area.

The design speed sets important parameters such as minimum horizontal curve radii and stopping sight distances, contributing to the overall safety and efficiency of the roadway. For this project, it was assumed that the design speed and posted speed would align. However, driver behaviour, flow of traffic, and geometric conditions influenced the selection of curves, the avoidance of abrupt changes, and the integration of environmental constraints.

Environmental factors such as quarries, NT land, established communities, and sensitive ecosystems were used to guide alignment shifts and while avoiding tighter curves, limiting impacts to surrounding areas and maintaining a safe design speed.

6.6.3 Horizontal Alignment Considerations

6.6.3.1 Horizontal Design

The horizontal alignment of the Proposed Project was developed based on a combination of engineering design criteria, safety considerations, and environmental constraints. The alignment adhered to design speeds, minimum radii, and superelevation rates, while also minimising impacts to the surrounding environment.

The selected alignment for the Proposed Project adheres to a minimum horizontal curve radius of 2,300 ft (701 m)**,** but larger radii were used where possible to provide smoother transitions and improve safety. Superelevation, the banking of the roadway around curves, was designed at 4% for most sections, based on guidance from the NRA. Superelevation rates were kept below 6% to limit the size of embankment slopes and maintain a balanced geometric design.

Key considerations in determining the horizontal alignment included:

- **Design Speed**: A design speed of 50 mph (80 km/h) was selected based on the roadway's functional classification as a Rural Principal Arterial. The design speed influences minimum curve radii, sight distances, and superelevation rates.
- **Consistency and Safety**: The alignment was designed to avoid abrupt changes in geometry, providing a more comfortable and consistent travel experience. Where possible, the use of minimum curve radii was avoided, prioritizing larger curves that enhance vehicle control, uniform speed, and overall safety.
- **Environmental and Geographic Constraints**: Several significant features, such as existing rock quarries, bodies of water (e.g., Meagre Bay Pond), and established residential and commercial properties, were avoided where possible. Environmentally sensitive areas, such as the CMW**,** the Mastic Reserve**,** and parrot nesting habitats**,** were also carefully considered when determining the alignment for the new roadway. These efforts also aided to minimise impacts on cultural and natural heritage resources while maintaining the functional integrity of the roadway.

The horizontal alignment also coordinated with the vertical profile to provide for smooth transitions and avoid steep slopes. Superelevation played a critical role in determining the horizontal alignment, especially around curves, to allow for enhanced vehicle safety by providing adequate banking for higher-speed travel.

6.6.3.2 Environmental and Design Trade-offs

The design of the Proposed Project aimed to balance environmental considerations with safety and operational efficiency. In some areas, the alignment was adjusted to avoid waterlogged and densely vegetated sections, which would have posed significant construction challenges and environmental impacts. For example, shifting the alignment away from the CMW reduced potential ecological damage while also ensuring the roadway's stability during storm events.

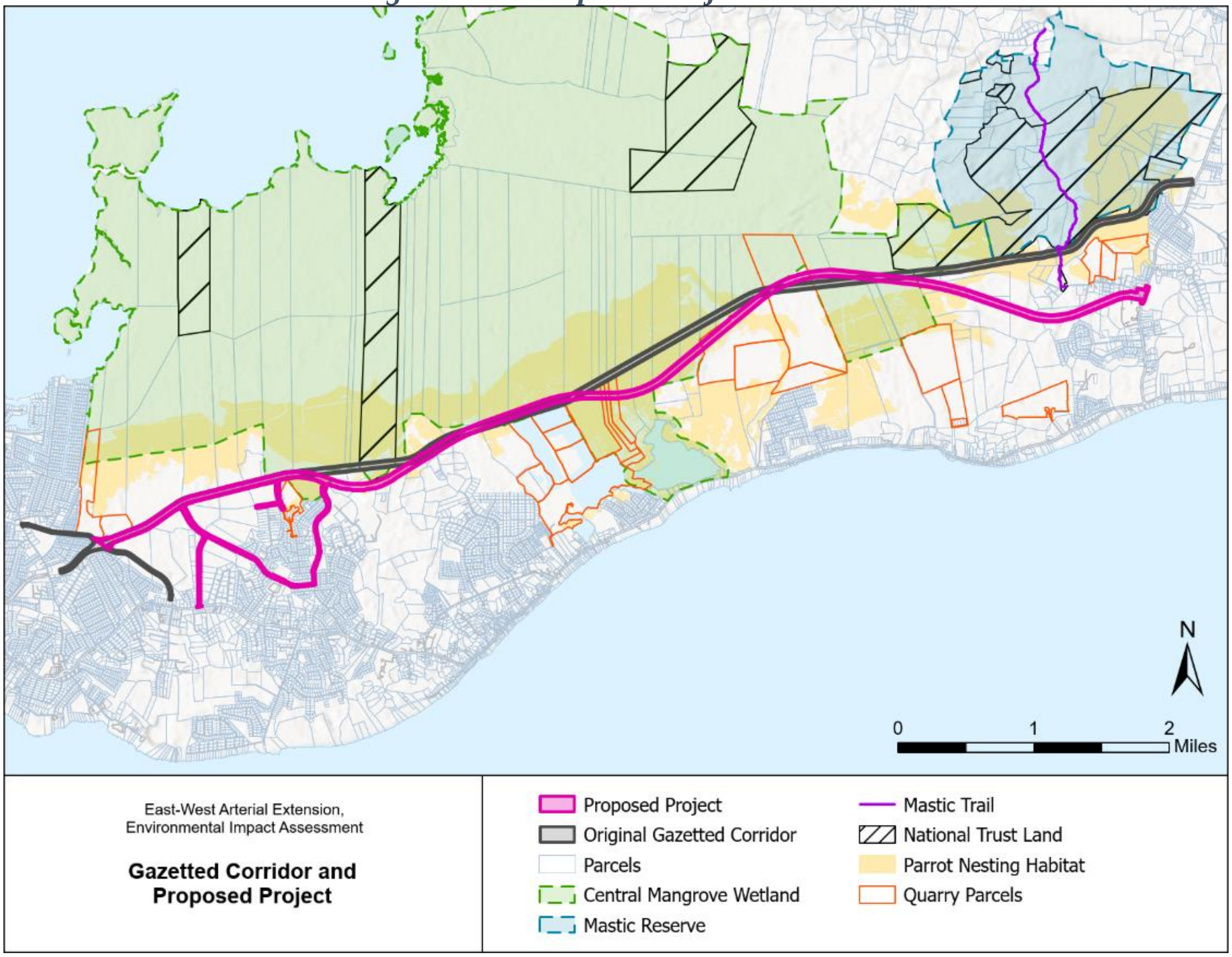
The subsequent chapters of this ES provide further details on the environmental trade-offs made as a result of the alignment design and refinement process, including impacts to Cultural & Natural Heritage**,** Geo-Environmental features**,** Socio-economics**,** and Terrestrial Ecology.

6.6.3.3 Comparisons to Gazetted Corridor

Comparisons between the original gazetted corridor (Section 26 Gazetted corridor as amended in March 2014) and the final Proposed Project alignment are presented in **Appendix F.4: Comparison to Original Gazetted Alternative.** These comparisons illustrate the modifications made to the location of the project corridor based on design and environmental considerations, highlighting areas where the roadway was shifted to best avoid or minimise impacts.

Figure 6-12 shows the proposed refined alignment for the Proposed Project, which balances safety, operational efficiency, and environmental sensitivity while providing a comfortable, consistent roadway for users.

Figure 6-12: Proposed Project Corridor



6.6.4 Clear Zone Requirements

Clear Zone refers to the unobstructed, traversable area provided beyond the edge of the travel way for the recovery of errant vehicles and includes shoulders and auxiliary lanes. The Clear Zone is to be free of fixed objects that pose a risk to vehicles that may collide with them. Objects within the Clear Zone that require shielding with a roadside barrier to protect errant drivers include non-breakaway sign supports or with a concrete base extending 4 inches (in) or more above the ground, bridge piers and abutments at underpasses, and light poles with high mast lighting. A Clear Zone of 22 ft (6.7 m) was determined for the travel lanes based on the design speed, traffic volumes, and roadside geometry. A clear zone of 12 ft (3.7 m) was determined for the transit lanes due to a lower volume of traffic.

Other non-traversable obstructions that may need consideration to be shielded to protect drivers is permanent bodies of water greater than 2 ft (0.6 m) deep, stone quarries and other open pit mining operations, and storage locations for hazardous substances. Every effort should be made to install new utility poles or plant trees outside the Clear Zone.

6.6.5 Vertical Grades, Cross Slopes, and Roadway Profiles

The vertical design of the Proposed Project is driven by several key criteria, including minimum and maximum vertical grades, cross slopes, sight distance requirements, and the vertical profile's interaction with drainage and stormwater management systems. The vertical alignment is essential for operational efficiency, stormwater drainage, and overall roadway safety.

6.6.5.1 Vertical Grades

The relatively level terrain of the study area set the minimum vertical grade at 0.3%**,** which is necessary to provide for effective stormwater drainage from the roadway surface. This minimum grade prevents water from pooling on the roadway during heavy rainfall events. The maximum vertical grade was limited to 3%**,** balancing material costs with the need to avoid steep inclines that could affect vehicle performance and increase construction complexity.

The vertical grade design also considers Grand Cayman's high rainfall levels and potential storm surge events. The vertical alignment was developed based on stormwater and storm surge data provided by Baird and RVE, using a 50-year storm event as the primary basis for determining the roadway's elevation. The use of this significant storm event is a conservative approach as it establishes the elevation of the roadway profile to height in which most of the roadway will remain unimpeded by storm surge and flooding. For additional stormwater and storm surge discussion, refer to **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** and **Appendices J.1 through J.6**. The profile was raised where necessary to minimise flood risks and to allow stormwater to recede quickly, reducing potential road closures during extreme weather. By initially designing for such an adverse situation, further refinement and optimization is possible by lowering the profile as needed in detailed design to reduce material need, environmental impact, and cost.

6.6.5.2 Excellent Fit Vertical Profiles

The vertical profile establishes the elevation changes along the centreline of the proposed roadway, ensuring proper drainage and smooth transitions between grades. The design of the vertical profile was closely integrated with the horizontal alignment to create a consistent and efficient travel experience for road users.

Bridge location**s** and hydraulic structures also influenced the vertical profile. To allow for sufficient clearance for stormwater and floating debris, 3 ft (0.9 m) of vertical clearance (freeboard) was provided between the low chord of the bridges and the 50-year design water surface elevation. This clearance helps avoid damming and ensures that hydraulic openings under bridges remain functional during high flow conditions. A minimum inspection clearance of 6 ft (1.8 m) from the existing ground surface was also maintained and a structure depth from the top of the structure to the lowest part underneath was assumed to be 2 ft (0.6 m). Additional elevation was given to account for the cross-slope of the road, especially in superelevated sections, so that the lowest edge of the pavement would meet the aforementioned elevation requirements. The profile elevation was raised at these locations to meet the required clearance while maintaining an efficient overall vertical alignment. On average, the profile elevation is approximately 10 ft (3 m) in height above the existing ground. During the detailed design, additional geotechnical and hydrological data will be collected and analysed, and each structure will be further evaluated individually to determine the optimal location, freeboard dimension, and vertical profile elevation. These alternations may influence the design of the overall vertical profile and necessitate additional alterations along the mainline. For example, a lower freeboard requirement for the bridge structures would lower the required bridge clearance and thus result in lowering the roadway profile at the bridge approaches reducing the amount of fill or embankment material needed to construct the roadway.

6.6.5.3 Good Fit Vertical Profile

The Good Fit vertical profile is conceptually designed to accommodate larger box culvert drainage structures instead of the bridge structures used in the Excellent Fit. This approach allows for a more optimized profile since the box culverts do not require the same elevation as bridge crossings.

Compared to the Excellent Fit, the Good Fit profile is at a lower elevation, reducing the overall volume of required fill while maintaining adequate stormwater conveyance. While the use of larger box culverts may necessitate additional drainage structures to meet the 25-year storm event, these culverts offer a longer service life and require less frequent structural maintenance than bridges but will require more frequent inspection to prevent debris deposits or blockage. Additionally, the Good Fit profile is more cost-effective than the Excellent Fit due to lower material costs and reduced structural complexity. However, the final spacing and sizing of these culverts must be refined in the detailed design phase to ensure they adequately convey design storm flows.

Further hydraulic modelling and analysis refinements will be required to finalize the culvert dimensions and confirm their effectiveness in handling anticipated flow rates. These refinements will directly influence the final vertical profile, ensuring the roadway remains cost-effective and resilient to 25-year stormwater impacts. The conceptual Good Fit profile is included in **Appendix F.1.1: Excellent Fit Corridor Roll Maps** for reference alongside the Excellent Fit profile.

6.6.5.4 Acceptable Fit Vertical Profile

The design criteria for the vertical profile in the Acceptable Fit option remain largely consistent with those outlined for the Excellent Fit, as discussed in **Section 6.6.5.2: Vertical Profiles**. However, the minimum required elevations have been adjusted based on the inclusion of reinforced concrete box culvert drainage structures, as shown in **Figure 6-15**.

These culverts have a 2-ft-high opening, with an additional 7.5-in top slab. To prevent structural damage from traffic loads, a minimum of 6 in of cover must be maintained from the top of the culvert to the bottom of the pavement structure. These requirements establish the minimum pavement elevation at the edge of the shoulder, which represents the lowest point in the section.

The conceptual vertical profile for the Acceptable Fit ranges from elevation 8.5 ft (2.6 m) to 13.5 ft (4.1 m), with an average of 10.5 ft (3.2 m). In terms of height above the existing ground, this corresponds to approximately 6 ft (1.8 m) to 8 ft (2.4 m), compared to 10 ft (3 m) to 12 ft (3.6 m) for the Excellent Fit. The conceptual profile for the Acceptable Fit is provided in **Appendix F.1.2: Acceptable Fit Corridor Roll Maps**, alongside profiles for the 25-year and 50-year storm event scenarios.

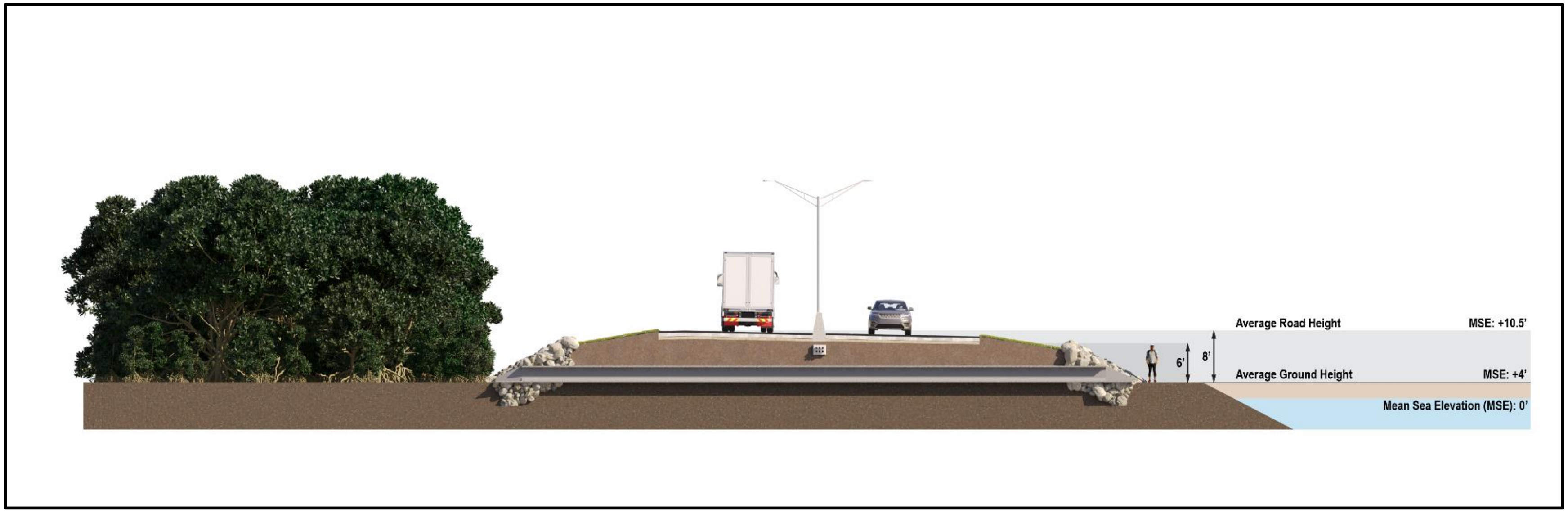
The profile will undergo further refinement during detailed design as drainage structure sizes and spacing are more precisely determined, and additional hydrologic modelling is conducted. A graphic rendering of the typical Acceptable Fit section is shown in **Figure 6-13**.

Figure 6-13 illustrates the typical cross-section and relative height of the Acceptable Fit. However, section heights will vary along the corridor due to several factors:

- **Superelevation (Banking on Curves):** In curved sections of the roadway, the outer edge of the road is raised higher than the inner edge—like how a racetrack is banked. This is called superelevation, and it helps vehicles navigate turns more safely by counteracting the natural outward pull (centrifugal force) that occurs when travelling around a curve. Without superelevation, vehicles would rely solely on friction to stay in their lane, which increases the risk of skidding, especially at higher speeds or in wet conditions.
- **Height of the Road Above Existing Ground versus Elevation Relative to Mean Sea Level (MSL):**
    - The height of the road above the existing ground refers to how much the roadway is elevated above the natural terrain at any given point. This varies along the corridor, typically ranging from 6 to 8 ft (1.8 to 2.4 m) in the Acceptable Fit.
    - The elevation relative to mean sea level (MSL) is an absolute reference point used to measure vertical position across different locations. For example, if the existing ground is at 2.5 ft (0.8 m) MSL and the new road is built 8 ft (2.4 m) above that, the top of the pavement would be at 10.5 ft (3.2 m) MSL.
    - This means that while the road elevation might be listed as 10.5 ft (3.2 m) MSL, the actual height of the road above the natural ground is only 8 ft (2.4 m), depending on the specific location along the corridor.
- **Existing Ground Variations:** The height of the roadway will fluctuate based on natural terrain changes.

Culvert Clearances: The vertical profile will need to be adjusted as needed to maintain proper clearance over the proposed box culverts discussed later in this chapter.

Figure 6-13: Acceptable Fit Section – Relative Height Graphic



A larger version of the above figure can be found in **Appendix F.3.2: Acceptable Fit Typical Sections**.

6.6.5.5 Cross Slopes

A cross slope of 2.5% was selected for the Proposed Project, slightly steeper than the typical 2% to accommodate the island's frequent heavy rainfall. This slope helps the water quickly drain off the road surface, reducing the risk of hydroplaning and other safety hazards. Steeper cross slopes were avoided to prevent vehicles from drifting toward the edge of the roadway, maintaining a balance between safety and effective drainage.

Cross slopes are critical in both tangent sections (straight segments of the road) and curved sections. The cross slope works in conjunction with the superelevation so that both straight and curved sections of the roadway are safe and efficient in various weather conditions.

6.6.6 Drainage, Stormwater, and Hydraulic Management

The vertical profile and cross slopes of the roadway play a critical role in the stormwater management for the Proposed Project. These elements are integral in directing stormwater to appropriate drainage inlets and outfall locations, ensuring that water is efficiently collected and channelled, reducing the risk of roadway flooding. As previously mentioned, the conceptual design for the new roadway's elevation was determined based on rainfall and storm surge projections for a 50-year storm. This elevation was chosen to aid in allowing sections of the new roadway to possibly remain operable during large-scale storm events. By elevating portions of the roadway, the design minimises flooding durations and ensures that traffic can resume normal operations as quickly as possible after a storm. The entire corridor has been designed to be elevated near the same level, including the micromobility and sidewalk facilities. Further hydraulic modelling based on site specific information will be completed during the detailed design process to further expand on the data from rainfall and storm surge. This additional analysis may further influence the roadway's elevation.

6.6.6.1 Drainage Features

In addition to the estimated potential bridge structures serving as hydraulic openings, a network of pipe culverts may be needed and has been strategically placed at intervals throughout the project corridor. These culverts span the full width of the roadway and manage water flow across the project area, enhancing hydrologic connectivity and reducing the risk of flooding.

The installation of these pipes and culverts will occur early in the construction process, spaced at approximately 300 ft (91 m) in wetland areas to maintain water flow between wetlands and mitigate flooding risks. The use of 48-in (1.2-m) diameter pipe culverts, each equipped with concrete end sections, has been proposed to facilitate hydrologic connectivity across the roadway and allow for drainage outflow from surface water collected by inlet catch basins. More detailed hydrologic modelling and analysis will be required in the detailed design stage to confirm these requirements. The influence of these culverts on the required water surface elevations for the design storm at the designated bridge sites has not yet been determined. It is expected that the culverts may enable a reduction in roadway elevation requirements for the detailed design storm event, but this will require validation through further hydrologic modelling during detailed design.

In areas where pipes and culverts are installed for hydraulic equalization purposes, the area may be temporarily blocked to accommodate construction activities. It is anticipated that most pipe and culvert installations can be completed early in each phase, to ensure that water flows are maintained throughout the construction process.

Further Refinements

The following aspects may require refinement during the detailed design phases:

- Pipe sizing and specific culvert locations based on more detailed hydrologic analysis.
- Profile elevation may need to be lowered because of accounting for the impact of the pipes and their set locations.
- Incorporating survey data to ensure optimal performance and integration with the overall drainage system.
- Implementing additional stormwater treatments, if required, to address evolving needs and any design refinements in the drainage systems.
- Evaluating the accessibility and maintainability aspects of the proposed drainage features, ensuring clear access routes, and developing a suitable maintenance plan and a contingency measures action plan for potential blockages.

6.6.6.2 Stormwater Management

In accordance with **Appendix E: Shortlist [Alternatives] Evaluation** completed earlier in the EIA process, along with subsequent project studies completed for the Proposed Project the conceptual design does not include traditional stormwater basins as a component of the stormwater management plan. Instead, the design leverages landscape buffers along the main corridor and enhanced storm drainage systems in upland areas to effectively manage stormwater. This approach focuses on minimising environmental and socio-economic impacts by avoiding traditional retention/detention basins, which are less effective in the tidally influenced zones characteristic of this project area. The use of linear buffers and conveyance devices aligns with overall project goals and constraints without necessitating extensive stormwater control facilities.

6.6.7 Hydraulic Structures

6.6.7.1 Bridges "Excellent Fit"

The evaluation of elevated structures for the Excellent Fit along the Proposed Project is an important component of designing the EWA Extension. The primary purpose of bridges within the corridor is to maintain hydraulic connectivity across the roadway embankment, minimising hydrologic impacts on the CMW, reducing flooding risks to adjacent properties, and ensuring that the roadway can recover quickly after major storm events. Additionally, the placement of bridges was assessed to aide in minimising impacts on environmental and cultural resources.

A series of hydraulic and hydrologic studies were conducted to conceptually estimate the required number, location, and size of hydraulic openings along the roadway embankment to manage both rainfall and storm surge events. For more detailed methodology and findings, refer to **Chapter 12: Hydrology and Drainage, Including Climate Resiliency.** Both bridges and cross culverts (e.g., box culverts or pipes) were considered for these hydraulic openings. The type, size, and location of structure at each opening depends on various factors, such as:

- Required opening size
- Geotechnical conditions
- Environmental and natural resource impacts

The following **Table 6-15** summarizes the number and size of the proposed bridge openings conceptually estimated along the Proposed Project. **Figure 6-14** illustrates these estimated structure locations.

Table 6-15: Summary of Bridge Openings for Proposed Project

Bridge Openings		
Number	**Length***	**Bridge Function**
7	330 ft (100.6 m)	Hydrologic Connectivity
8	150 ft (45.7 m)	Hydrologic Connectivity

**Length is clear opening between abutment faces.*

Section 2 of the corridor features six (6) structures, each with a 330-foot opening, accounting for approximately 56% of the total bridge structure area. In contrast, Section 3 includes nine (9) structures; one has a 330-foot opening while the remaining eight (8) have 150-foot openings, making up about 44% of the total bridge area. In addition to the estimated 15 larger bridge openings, smaller hydraulic openings (e.g., pipes or small box culverts) may also be required at specific locations to address localized drainage needs pending more detailed hydrologic modelling. The use of bridges is suggested at key locations along the Proposed Project corridor where the larger hydraulic openings are necessary to maintain flow across the embankment.

Once the construction site is stabilized, the earthwork would then commence for bridge foundations, which will be designed during the detailed design phase based on geotechnical information. The geotechnical information will be utilised to inform and govern the precise configuration of piers and abutments. Geotechnical stabilization may also be required in certain areas with poor soil conditions, and the detailed design will take into account hydrologic functions and vehicular traffic, ensuring that bridges support both transportation needs and environmental protection**.**

Overall, the use of bridges will play a critical role in aiding uninterrupted water flow beneath the roadway along with minimising adverse impacts on wetlands**,** watercourses, or other sensitive areas. Areas with significant environmental importance, such as the CMW, are suggested to be given special attention so that bridges provide the necessary hydraulic performance while adhering to environmental commitments. Concept plans for these proposed structures can be found in **Appendix F.2: Bridge Structure Concept Plan Sheets**.

Figure 6-14: Bridge Opening Locations for Proposed Project

Future Build Years and Bridge Widening

Typical sections for the estimated potential bridge crossings were developed in conjunction with the overall roadway typical sections, which are presented in **Appendix F.3.1: Excellent Fit Typical Sections**. The projected future bridge configuration for the year 2060 includes:

- A vehicular bridge with four general-purpose vehicular travel lanes divided by a median barrier.
- Two dedicated transit lanes, separated from travel lanes by a median barrier.
- A separate bridge that would accommodate a sidewalk and a micromobility path.

Since the initial construction will not require this full capacity, typical bridge sections have been developed for the years 2026, 2036, 2046, and 2060. These sections illustrate the progression of bridge widenings and facility expansions to meet future demands. The estimated phasing of these expansions include:

- **2026 Initial Build Year**: two travel lanes and the necessary hydraulic openings.
- **2036 and Beyond**: Each bridge constructed in the initial build year 2026 would undergo widening to support the increased number of travel lanes along with the addition of a separate pedestrian/micromobility bridge. The pedestrian and micromobility bridge will be

designed to accommodate lighter loads and emergency vehicles, while also ensuring minimal disruption to the main roadway's horizontal alignment.

While bridge widening presents challenges—such as maintaining traffic flow during construction and protecting existing structures—these are standard practices in the expansion of transportation facilities. It is recommended that ongoing monitoring of the stability of bridges be conducted during the future construction phases.

Additional considerations for the structures, such as utility features and lighting, are discussed in **Section 6.6.11: Utilities**.

Hydraulic and Structural Considerations

The vertical profile of the roadway for the Excellent Fit was designed to accommodate bridges and other hydraulic structures to maintain connectivity and ensure the roadway's operability during extreme weather events. Bridges are preferred over box culverts in locations requiring larger hydraulic openings, as they allow for greater flow capacity while minimising impacts to environmentally sensitive areas like wetlands.

To minimise further elevation increases in the roadway's vertical profile, shallow structure depths are preferred. Therefore, as part of this conceptual design phase, a cast-in-place flat slab structure has been assumed, with span lengths of 30 to 40 ft (9.1 to 12.2 m) and a slab depth of less than 2 ft (0.6 m). Potential support options include reinforced concrete wall piers and abutments or concrete pile bents. Based on existing geotechnical data, shallow spread footing foundations are expected to be feasible at most locations, although deep foundations may be necessary in areas with deeper rock formations. A set of Bridge Structure Concept Plan Sheets, which illustrate the assumed structure type at this phase of the design, is included in **Appendix F.2: Bridge Structure Concept Plan Sheets**.

Further Refinements

Intersection and/or structure location adjustments will be necessary during the detailed design phase to avoid sight distance concerns associated with structures near intersecting traffic.

By integrating these drainage, stormwater, and hydraulic considerations, the project design ensures effective water management while balancing safety, operational efficiency, and environmental protection.

6.6.7.2 Large Box Culverts "Good Fit"

The Good Fit drainage system is conceptually designed to efficiently manage stormwater while reducing costs and improving constructability. Instead of the bridge structures used in the Excellent Fit, the Good Fit relies on larger box culverts for major water crossings, accommodating moderate storm events and surge flows. This approach reduces construction complexity while maintaining adequate hydrologic connectivity. Additionally, pipe culverts should be strategically placed to facilitate cross-drainage and minimise localized flooding.

To effectively convey the 25-year storm event, additional large box culverts may be required. However, further hydraulic analysis during detailed design will determine the final size, spacing, and invert elevations necessary to prevent roadway overtopping and maintain efficient flow paths across the corridor.

Resiliency Considerations

From a resiliency perspective, adopting a 25-year storm event instead of a 50-year event slightly reduces the roadway's ability to withstand extreme storm events but maintains a "good" level of resiliency that is able to meet the conditions for resiliency as defined in the CSFs as seen in **Table 6-1**. This approach aligns with EAB and NRA criteria, ensuring the roadway remains functional, cost-effective, and resource-efficient while still providing sufficient stormwater management. The design remains robust enough to handle less severe weather events effectively, balancing resiliency, cost efficiency, and sustainability without significantly compromising long-term performance.

Further refinements in detailed design will ensure that the Good Fit drainage strategy aligns with final hydraulic modelling results, confirming that the system is adequate, cost-effective, and resilient under design storm conditions.

6.6.7.3 Small Culverts "Acceptable Fit"

The hydraulic structures in the Acceptable Fit differ significantly from those in the Excellent Fit, primarily due to the lower stormwater volumes anticipated for less severe storm events. The Excellent Fit includes large bridge openings, designed to maintain hydrologic connectivity under a 50-year storm surge and rainfall event, ensuring that stormwater can be effectively conveyed without roadway submersion.

In contrast, the Acceptable Fit does not include bridge structures, as it has been conceptually developed for less extreme storm conditions. The drainage system for the Acceptable Fit relies on smaller hydraulic openings using culverts rather than bridges. The reduced size and distribution of openings in the Acceptable Fit reflects the lower anticipated water volume from smaller, more typical storm events, determined based on the approach outlined in the hydraulic assessment below and in the **Acceptable Fit Preliminary Drainage Calculations** section.

Although the total area dedicated to hydraulic openings varies significantly between the Excellent Fit and Acceptable Fit options, this difference is not an arbitrary design choice. In the Excellent Fit, bridges were incorporated to effectively manage stormwater runoff and storm surge following a 50-year storm event, ensuring that critical sections of the roadway remain operable during extreme conditions. These structures were not artificially introduced but were identified as essential for maintaining flood resiliency and long-term roadway functionality under severe storm impacts.

It should also be noted that during moderate storm events, such as a 25-year or 50-year event, the combination of intense rainfall and storm surge would likely result in more frequent and more severe levels of water overtopping the roadway at some locations for the Acceptable Fit as compared to the Excellent and Good Fits. The Acceptable Fit approach does not prevent overtopping but focuses on effective post-storm drainage to restore roadway functionality as quickly as possible. Additionally, the Acceptable Fit prioritizes smaller, more typical rainfall events, striving to manage everyday drainage needs managed efficiently while balancing cost and constructability.

For the Excellent Fit option, the roadway profile and proposed openings were designed and sized at a proof-of-concept level of modelling to handle the flows from a 50-year storm surge and rainfall event (i.e., hurricane level event) while keeping the road in a drivable condition. The Acceptable Fit option has not been modelled or analysed for a storm event. The preliminary drainage calculations discussed below are analysing a non-dynamic pool of water against one side of the road and the amount of time it takes to drain this water. They are not associated with a design storm. Analysis and modelling will be required during the detailed design phase to determine the effects of storms on the Acceptable Fit option.

Acceptable Fit Preliminary Drainage Calculations

For the Acceptable Fit option, two potential drainage configurations were evaluated to estimate the required number and size of culverts:

- 2-ft diameter circular pipe culverts
- 2-ft high by 4-ft wide box culverts

The calculation was performed using the equation for flow through an orifice and assumes free-flow conditions on the downstream side, which would be equivalent to having no water on the North Sound side of the proposed road. The volume of water to be drained was calculated using surface area and water depth. The surface area was estimated as the amount of area flooded for the 7 ft (2.1 m) to 9 ft (2.7 m) desired elevation of the roadway profile based on the island topography, which would result in the worst-case scenario for the roadway water impoundment. The surface areas were approximated for areas that appeared to by hydraulically separated (i.e., pools of water separated by the island topography on one side and the road on the other side). The water depth was estimated by using the minimum height of the roadway profile over the length of these "pooled" areas. A 48-hour timeframe was selected as the required amount of time for the standing water to drain from one side of the road to the other. The 48-hour timeframe could be adjusted to 24 or 36 hours resulting in an increase in the required number of pipes or box culverts.

Culvert Requirements & Preferred Configuration

The results of the preliminary drainage calculations are summarized in **Table 6-16**. The calculations have identified the need for either:

- 222 of the 2-ft diameter circular pipe culverts (**Figure 6-15**), or
- 90 of the 2-ft high by 4-ft wide box culverts (**Figure 6-16**)

to drain stormwater from one side of the road to the other within 48 hours. The spacing between the box culverts reflects their increased capacity, making them a preferred option due to several advantages:

- Enhanced sediment transport capabilities due to their larger cross-sectional area.
- Easier installation and maintenance.
- Fewer units needed, which offsets the higher per-unit cost.
- Enhanced durability and sufficient passageway for local wildlife, promoting ecological connectivity.

Table 6-16: Number and Spacing of Drainage Structures for the Acceptable Fit Option

Station Location	2-ft Pipe Culverts	Spacing (ft)		2-ft by 4-ft Box Culverts	Spacing (ft)
Begin Project to 1094+00	11	783		5	1566
1094+00 to 1115+50	12	165		5	358
1115+50 to 1144+00	31	89		13	203
1144+00 to End Project	168	162		67	403
Totals	**222**			**90**	

In the Acceptable Fit approach, the 48 in (1.2 m) diameter pipe culverts originally proposed for stormwater conveyance are no longer required due to the lower roadway profile. Instead, smaller culverts would be used to maintain necessary hydraulic connectivity while accommodating the reduced profile elevation. The final sizing and placement of these culverts will be refined during the detailed design phase through detailed hydrologic modelling and survey data to ensure proper drainage performance. Additionally, these adjustments may influence profile elevations, culvert installation sequencing, and hydrologic modelling refinements during final design. Despite these modifications, the overall stormwater management strategy remains unchanged, ensuring that water flow is effectively maintained across wetland areas while aligning with project drainage goals as discussed in **Section 6.6.6: Drainage, Stormwater, and Hydraulic Management**.

Figure 6-15: 24" Reinforced Concrete Pipe Example

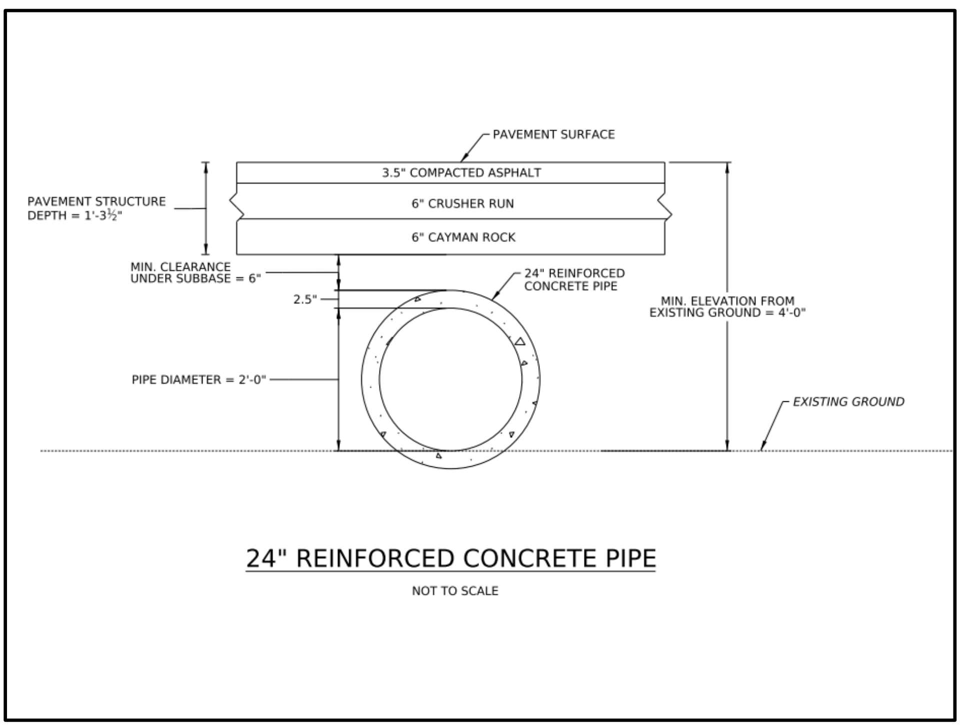
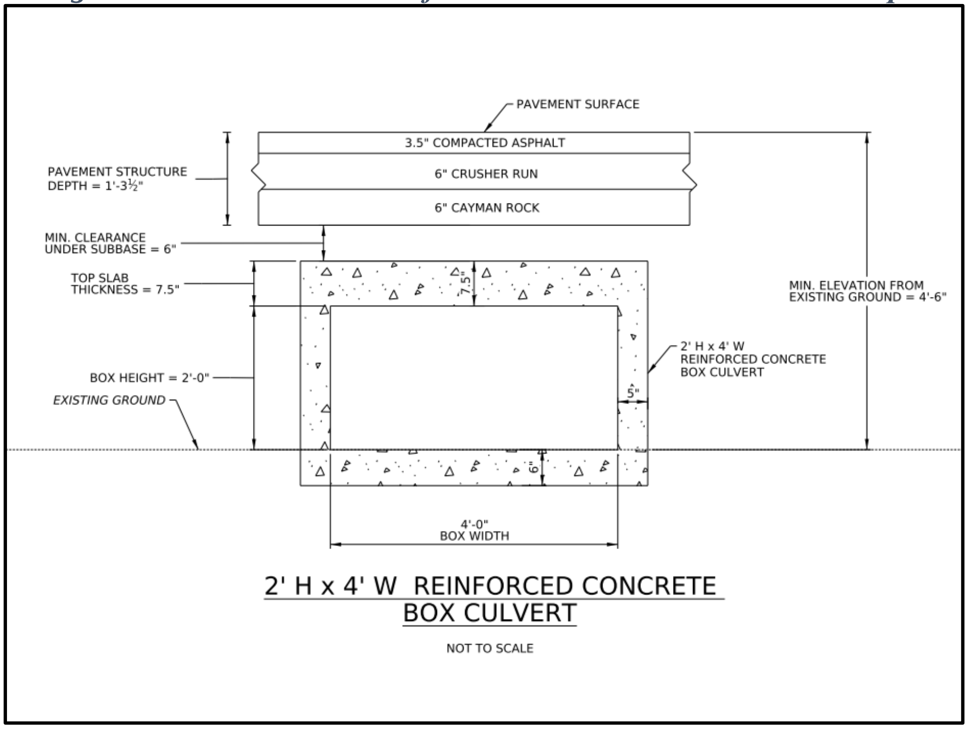


Figure 6-16: 2'H x 4'W Reinforced Concrete Box Culvert Example



Storm Surge & Extreme Storm Resiliency

The Acceptable Fit option maintains baseline resiliency standards, ensuring compliance with the CSFs as seen in **Table 6-1,** and adhering to EAB and NRA criteria. However, further hydrologic and hydraulic analysis will be required during detailed design to evaluate the system's ability to manage extreme storm events and storm surge conditions effectively.

Since the roadway is elevated, routine rainfall is not expected to cause drainage issues. However, during extreme storm events, particularly those involving storm surge or heavy flooding, water levels may temporarily rise above portions of the roadway. To address these risks, the detailed design of the project will focus on:

- Risk of Roadway Submersion – Assessing where and to what extent floodwaters may rise above the roadway during severe storms.
- Emergency Access & Functional Resiliency – Identifying critical sections that must remain passable for emergency response and evacuation for as long as possible during a storm event.
- Optimised Drainage Outfalls – Ensuring that outfall locations allow for efficient removal of standing water.
- Embankment & Erosion Protection – Implementing reinforced embankments, scour protection, and erosion control to prevent washouts and structural degradation from floodwaters.
- Efficient Water Movement – Optimising drainage systems to ensure that excess water moves away from the roadway as quickly as possible, preventing prolonged inundation.

- Flood-Resistant Design Features – Incorporating durable pavement materials, reinforced embankments, and water-resistant drainage systems to withstand prolonged water exposure, minimising structural damage and reducing long-term maintenance needs.

The detailed design phase will refine these considerations to ensure that the Acceptable Fit remains a cost-effective yet resilient solution that balances storm surge tolerance, roadway protection, and long-term functionality within the overall project framework.

Hydrological & Environmental Risk Management

The Acceptable Fit drainage option prioritizes cost efficiency and practicality for typical storm conditions, rather than extreme storm events with storm surges. However, the detailed design phase must rigorously evaluate the long-term performance of the drainage system to prevent unintended consequences such as:

- Localized flooding
- Excessive sediment transport
- Water quality degradation

To mitigate these risks, key considerations include:

Long-Term Maintenance & Adaptive Management

- Regular culvert inspections and cleaning schedules to prevent blockages from sediment, debris, and vegetation build-up.
- Post-construction flow monitoring to determine whether sedimentation or clogging issues require additional mitigation.

Sedimentation & Debris Control Measures

To improve long-term performance, Best Management Practices (BMPs) may be implemented, including:

- Sediment traps at pipe inlets to reduce sediment build-up.
- Trash racks to prevent clogging from large debris during extreme storms.

Potential Future Drainage Adjustments

While initial calculations for the Acceptable Fit indicate that 222 pipe culverts or 90 box culverts would be required, further refinements in the detailed design phase may include:

- Larger-width culverts (e.g., 2-ft x 6-ft or 2-ft x 8-ft box culverts) to improve drainage efficiency while reducing the total number of required structures.
- More frequent culvert spacing in critical areas to optimize runoff movement.

By integrating proactive maintenance plans, sediment control strategies, and potential design refinements, the Acceptable Fit drainage option can be optimised for long-term sustainability, ensuring cost-effectiveness while maintaining hydrological balance and flood resiliency.

6.6.8 Future Multimodal Facilities

The Proposed Project incorporates a comprehensive approach to accommodate multimodal facilities, including pedestrian and micromobility infrastructure, with provisions designed to ensure safe, accessible, and future-ready pathways. These design elements comply with the ToR, addressing diverse travel modes on the island—including walking, jogging, biking, and the growing use of micromobility devices like electric scooters and bikes.

A 10 ft (3.0 m) wide sidewalk will run the entire project length, providing ample space for high pedestrian activity, and supporting various uses, such as walking, jogging, and casual cycling. Designed for both travel and leisure, this sidewalk offers sufficient width to ensure comfort and safety for all users.

To accommodate faster, variable-speed micromobility devices, a 14 ft (4.3 m) wide asphalt micromobility path is planned alongside the sidewalk. This path will support electric scooters, bikes, and other lightweight vehicles. A buffer separates the sidewalk from the micromobility path, enhancing safety by accommodating the different speeds and sizes of users.

For a visual overview, **Figure 6-17** illustrates various micromobility devices in use, as referenced from the Pedestrian and Bicycle Information Centre publication, "The Basics of Micromobility and Related Motorized Devices for Personal Transport."

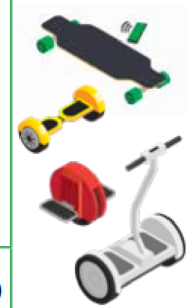
With future integration in mind, the pedestrian and micromobility facilities are designed to connect seamlessly with potential multimodal transit options, including Bus Rapid Transit (BRT) lanes and related transit features. Specific future-oriented provisions include:

- Strategic placement of bus stops and shelters along the pedestrian corridor.
- Crosswalks and designated pedestrian access points at intersections to optimize connectivity with transit systems.

Additionally, smart infrastructure technologies, such as real-time monitoring systems for pedestrian and micromobility traffic, can be incorporated to enhance safety and improve operational functionality.

Another CSF of the project is the need to provide opportunity for enhanced and safe pedestrian and bicycle travel. This is achieved through the implementation of the sidewalk and micromobility path facilities that span the length of the project and interconnect with adjacent communities and infrastructure.

Figure 6-17: Common Micromobility Devices (Sandt, 2019)

	Electric standing or sitting scooters (e scooters)	Electric bicycles (e-bikes)			Other[1]
Device					
		Class 1 Pedal assist (pedalec)	Class 2 Throttle assist	Class 3 Pedal assist (pedalec) at higher speed	
Example brands	**Shared:** Bird, Lime, and many others **Owned:** Inboard Glider, Segway 9Bot	**Shared:** Lime, Mobike, Ofo, Pace, Spin, and many others **Owned:** Most major bike brands; multiple passenger versions include Organic Transit (ELF) and Yuba	**Owned:** Several bike brands (less common than Class 1 and 3)	**Owned:** Several major brands; multiple passenger versions include Better Bike (PEBL), and Podride	**Owned:** Boosted, Inboard, Mellow Boards, Metroboard
Weight	Typically < 50 lbs	Typically < 100 lbs; multiple passenger versions near 200 lbs	Typically < 100 lbs	Typically < 100 lbs; multiple passenger versions near 200 lbs	< 50 lbs
Occupants	Single rider	Usually a single rider; some cargo e-bikes or bike cars designed for multiple riders	Typically designed for single riders	Usually a single rider; some designed for multiple riders	Single rider
Power supply	Electric motor typically < 750 watts	Electric motor typically < 750 watts	Electric motor typically < 750 watts	Electric motor typically < 750 watts	Electric motor typically < 750 watts
Product speed[2]	20 MPH or less; some cities apply additional speed restrictions	20 MPH or less	20 MPH or less	28 MPH or less	Most are 20 MPH or less though some can go up to 30 MPH
Operating space	Varies by place;[3] some cities restrict in crowded places	Varies by place;[3] usually allowed on bike transportation facilities and paths	Varies by place;[3] usually allowed on bike transportation facilities and paths	Varies by place;[3] some States restrict access on bike paths	Varies by place[3]
Regulated by	Consumer Product Safety Commission (CPSC), for personally owned devices[4]	CPSC (only for personally owned devices)	CPSC (only for personally owned devices)	CPSC (only for personally owned devices)	CPSC (only for personally owned devices)

[1]This category includes e-skateboards; e-skates; e-boards or other self-balancing devices (sometimes called hoverboards or balance wheels.)

[2]Speed intended for usage by manufacturer; this may be regulated by State or local ordinances and may differ from actual operating speeds or modifications made by the device user.

[3]In some circumstances, paths may have restrictions based on the Federal or State regulations, or the source of funding. These restrictions are often marketed at the entrance to the facility, but not always.

[4]CPSC is a regulatory body that identifies if a product is safe to sell in the U.S. under the Consumer Product Safety Act. It does not regulate who can purchase a device or where or when devices can be legally ridden.

5Moped/scooter/motorcycle definitions are highly variable by State. For example, in North Carolina, there is no separate category for scooter; "scooters" may be mopeds or motorcycles depending on engine capacity. These devices and motorcycles are often regulated at the Federal level through the Consumer Product Safety Commission, although they are not regulated by the Federal Motor Vehicle Safety Standards (FMVSS). Still, States may define and regulate them at the State level and enforce regulations through the Department of Motor Vehicle (DMV) or other mechanism.

6.6.9 Intersections

The suggested intersection types and their potential locations along the Proposed Project have been strategically selected to provide safe and efficient traffic flow for multiple transportation modes. Intersection placement was carefully considered to enhance connectivity with existing routes, facilitate access to adjacent developments, and address factors such as property impacts, GHG emissions, and access limitations to the northern project area. Two main categories of intersections are proposed, as shown in **Table 6-17** as well as **Figure 6-19**, which have been incorporated to serve minor connector roads linking existing and future residential and commercial areas.

6.6.9.1 Full Access Intersections

The Full Access intersections provide unrestricted vehicle movement in all directions. The two types of Full Access intersections proposed include:

- **Roundabouts**:
    - The tie-in point between Section 2 of the Proposed Project and Section 1 at Woodland Drive and Agricola Drive.
    - The intersection of Frank Sound Road at the eastern end of the Proposed Project.
- **Restricted Crossing U-Turn (RCUT):** This type of intersection is proposed at Lookout Road due to the anticipated high volume of right-turns from the Proposed Project onto Lookout Road.

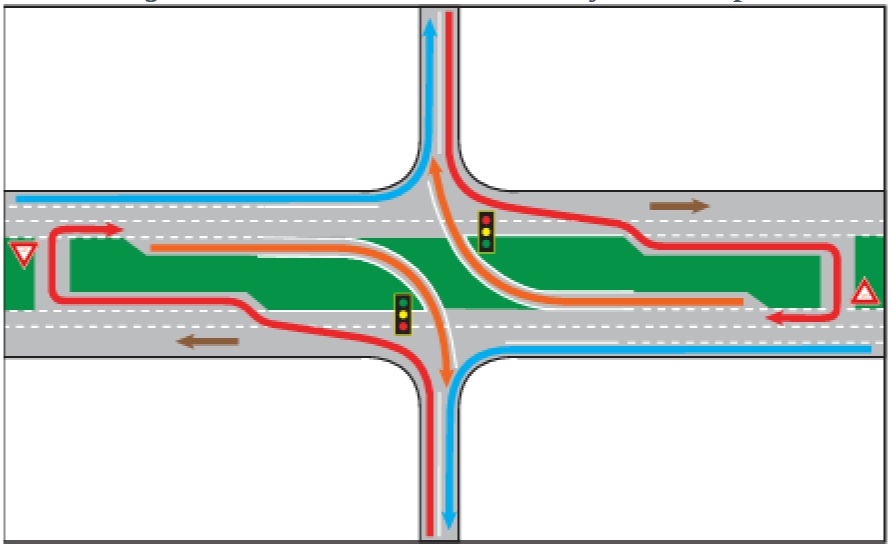
RCUT's are a type of intersection design that requires drivers on side streets to turn left and then make a U-turn to continue in their desired direction. This design helps reduce the likelihood of dangerous right-turn movements across multiple lanes of traffic and improves the overall safety and efficiency of intersections.

Key features of RCUT's include:

- Left turns only for exiting side street traffic, followed by a U-turn to complete the desired movement.
- Enhanced safety by eliminating right-turn conflicts.
- Improved traffic flow with separate U-turn lanes for vehicles making a right turn.

Appendix F.5: Lookout Road Intersection Build Year Progression depicts the RCUT intersection at Lookout Road and how it is expected to develop over the different build years. **Figure 6-18** below is an example of an RCUT intersection in the United States (U.S.).

Figure 6–18: RCUT Intersection Layout Example



Source: Indiana Department of Transportation, USA

6.6.9.2 Partial Access Intersections

Partial Access intersections provide more restricted movements. These include left-turn in, left-turn out configurations, as well as median U-turn locations. The purpose of these access points is to offer a balance between local access and maintaining traffic flow along the Proposed Project. Key features include:

- Median U-turns are proposed at key points to facilitate traffic from side streets to safely change direction when needed to allow access to roadways on the opposite side of the barrier and provide means of exiting the roadway during incidents.
- Two of these U-turn locations (each direction) are recommended to be designed to accommodate emergency vehicles, providing a connection to either direction for faster response times along the corridor.
- Southern access points will be introduced in 2026 while Northern access points will not be introduced until future year 2036.

6.6.9.3 Detailed Intersection Configurations for 2026 and 2036 Build Phases

For the 2026 build phase, Section 2 of the Proposed Project will include two full access intersections: a roundabout at the Agricola connector and an RCUT at Lookout Road. Additionally, six partial access (left in/left out) intersections will facilitate access to the southern side of the corridor. Two designated U-turn locations spaced at approximately 1.5 mi will allow eastbound vehicles to access the southern side, and one U-turn near Lookout Road will cater to westbound vehicles accessing the northern side. In Section 3, there will be one full access intersection, a roundabout at Frank Sound Road, along with three partial access (left in/left out) intersections for southern side access only. Similarly, three U-turn movements for eastbound vehicles and one for westbound vehicles at the midpoint will enhance connectivity and emergency service access across the corridor. By the 2036 build phase, Section 2 will see the addition of two partial access (left in/left out) intersections at northern access points and the addition of northern access at the RCUT at Lookout Road. Section 3 will also add four partial access (left in/left out) intersections, further enhancing the corridor's accessibility and functionality.

Table 6-17: Proposed Full and Partial Access Intersections

Proposed Intersections			
Full Access 2026		**Partial Access 2026**	
Roundabout	RCUT	Southern	Northern
2	1	9	0
Full Access 2036		**Partial Access 2036**	
Roundabout	RCUT	Southern	Northern
2	1	9	6

6.6.9.4 Multimodal Considerations

The intersection designs have been prepared to account for future integration of pedestrian, bicycle, and micromobility facilities, as well as transit lanes. Transit is outside of the ambit of the NRA, but for the purposes of the EIA, the transit lanes have been envisioned to be BRT lanes. In the future, the following features have been considered:

- Dedicated BRT lanes to be constructed on the southern side, with a sidewalk, micromobility pathway, and bus stops adjacent to the transitway at each of the proposed intersection locations.
- Signalized at-grade crossings to aide in providing safe passage for BRT vehicles at intersection locations along the corridor.
- Roundabout locations at the termini, with the assumption that BRT lanes will terminate at signal-controlled T-junctions in the southern approach of the roundabouts.
- Other options, such as overpasses or the integration of BRT lanes into general purpose travel lanes at key intersections, may also be considered in future design stages based on evolving transportation needs.

Through the implementation of transit lanes and corresponding facilities, the project can strive to meet the CSF of providing opportunity to safely accommodate and expand public transportation. Further discussion how this CSF can be met can be found in **Chapter 8: Socio-Economics**.

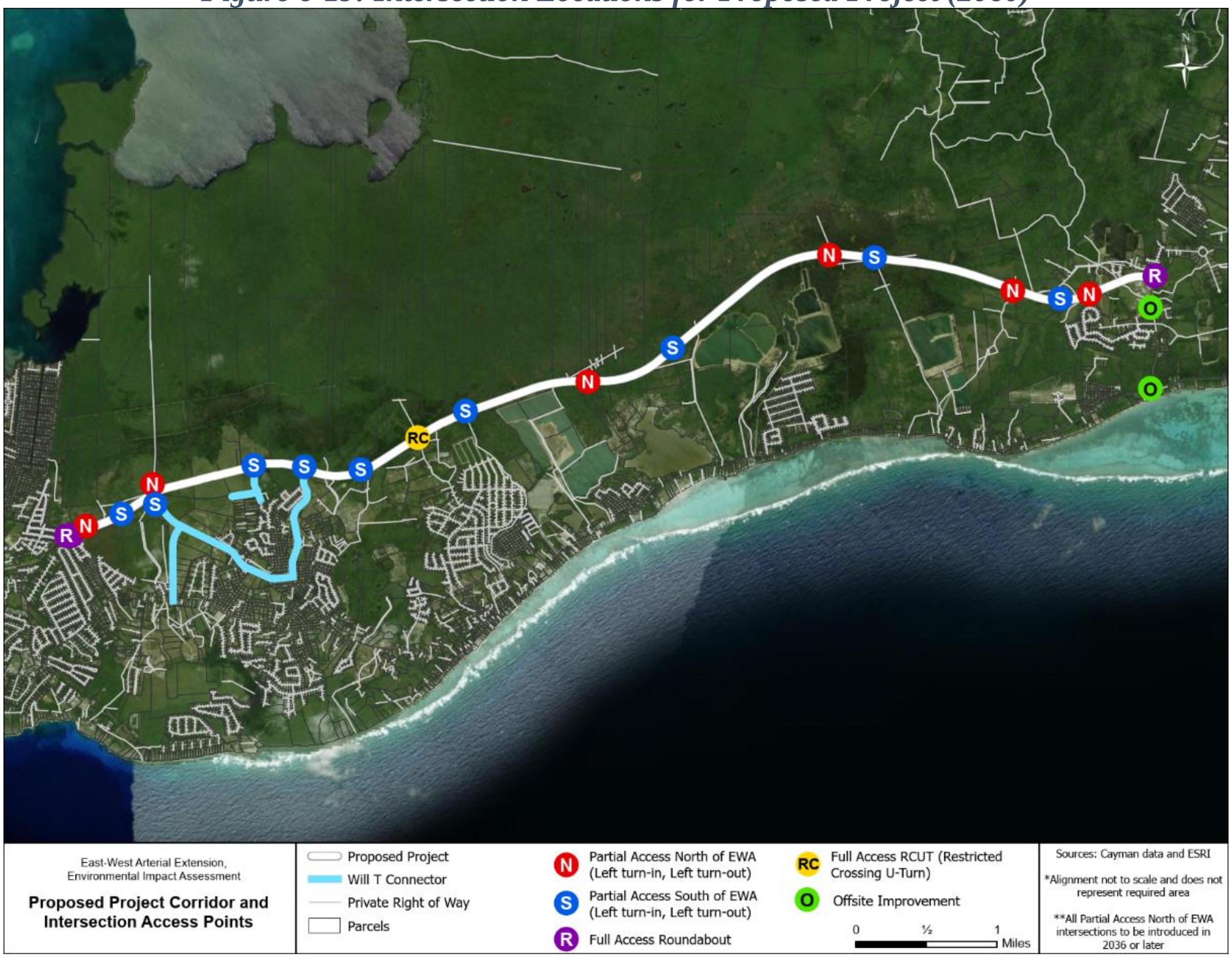
6.6.9.5 Off-site Intersection Considerations

Two additional intersections outside of the corridor limits of the Proposed Project (shown in **Figure 6-18**) were also evaluated for functionality, cost, and environmental impact including:

- **Frank Sound Road and Bodden Town Road**: A full access, signal-controlled intersection was evaluated.
- **Frank Sound Road and Clifton Hunter High School driveway**: A full access, signal-controlled intersection was evaluated.

Figure 6-19 below shows the location of the types of intersections along the corridor. Partial access intersections to the north and south are represented by an "N" and "S" respectively. The full access intersections are represented by either an "R" for roundabout or "RC" for RCUT, while the offsite improvement locations by an "O".

Figure 6-19: Intersection Locations for Proposed Project (2060)



6.6.9.6 Intersection Design Considerations

As the conceptual design progresses into detailed design, the suggested locations of intersections and the potential bridge structures will be re-evaluated to avoid design conflicts and to provide for optimal sight visibility. Other design features will also be refined during the detailed design after additional analysis efforts including:

- Truck turning movements using vehicle simulation software should be applied at all full and partial intersection locations.
- Intersection sight distance calculations should be completed for all full and partial access intersections.
- Evaluate Roundabout performance per National Cooperative Highway Research Program (NCHRP) Report 1043. Detailed designer should conduct performance checks and revise the approach and circular geometry to meet the design and performance objectives. The following are a list of performance checks:
    - Geometric Speeds

  - Sight distance and visibility
  - Vehicle path alignment
  - Design vehicle Checks
  - Bicycle and Pedestrian Design Flags
  - Pedestrian crossing assessment
  - Pedestrian wayfinding assessment

The provision of the combination of Full and Partial Access intersections at several existing and potential access points is another way the project meets CSFs by providing safe and efficient intersection types. Further information on safety and intersections can be found in **Chapter 7: Transportation and Mobility.**

6.6.10 Coordination with Future Land Use and Infrastructure Needs

Coordination with future land use and infrastructure needs is an important design consideration for the Proposed Project. The roadway should accommodate not only current development patterns but also provide flexibility for future growth in residential, commercial, and industrial sectors. Key aspects include:

- **Integration with Planned Developments**: The design accounts for known future community developments throughout the EWA study area, including provisions for access points, utilities, and public transit to meet increased demand.
- **Utility Corridor Expansion**: Space for utilities has been designed to allow future developments to connect with minimal disruption. Additional empty conduit can be placed during initial construction to reduce future excavation needs.
- **Adapting to New Technologies**: As new mobility technologies—such as electric vehicle (EV) infrastructure, autonomous vehicles, and renewable energy systems—become more prevalent, the roadway's design will support potential future upgrades to accommodate these innovations.

By aligning the design with future infrastructure and land use needs, the Proposed Project aims to remain adaptable and capable of supporting Grand Cayman's long-term development.

6.6.11 Utilities

The Proposed Project includes provisions for both existing and future utilities within the proposed roadway corridor. Specific space has been allotted on both the north and south sides of the corridor to accommodate various utilities such as sanitary sewer, water, fibre optics, and electricity. These designated utility zones are integrated into the typical section, which is detailed in **Appendix F.3.1: Excellent Fit Typical Sections**. In addition to these utility spaces, electrical duct banks are proposed alongside the roadway to support highway lighting and the potential installation of a solar panel canopy. However, note that utilities are outside of the ambit of the NRA.

6.6.11.1 Utility Coordination

Effective coordination with utility providers is an important component so that the design elements meet utility requirements and construction proceeds smoothly. Early collaboration with utility companies would help in mitigating service disruptions and ensuring adequate space for existing and future utility needs. More detailed integration of various utility services within the roadway design will be confirmed following a more in-depth coordination with the relevant 3rd parties during detail design phase.

6.6.11.2 Future-Proofing

The conceptual design for the Proposed Project takes into account future growth by providing additional capacity for utilities. Empty conduits may be installed during initial construction to avoid unnecessary future excavation and to allow for easy expansion or upgrades. This foresight will help minimise disruptions to the roadway in the long-term and reduce future construction costs.

6.6.11.3 Utility Protection

Protective measures for key utilities such as major electrical lines, water mains, and fibre optics should be implemented to safeguard them during both construction and future roadway maintenance activities. For instance, reinforced concrete encasement or other protective barriers may be considered to shield utilities from potential damage in areas of concern. Such strategies will be important to consider in areas where utilities traverse sensitive environmental features.

6.6.11.4 Utility Resiliency

Given the region's susceptibility to extreme weather events like hurricanes and flooding, utility infrastructure should be best designed for resiliency. In vulnerable areas, utilities may be buried deeper or reinforced to withstand such events. It is recommended that the utility providers consider the use of storm-resistant materials and integrate redundancy in critical services (e.g., electrical and water supply) to provide for continuous service during and after natural disasters.

6.6.11.5 Utility Considerations at Structures

At bridge or structure locations, various options for utility crossings and features would be evaluated during the detailed design phase. Utilities can either be buried underground beneath the structure, mounted to the outside of the bridge barriers, or even provided with dedicated utility bridges, if required. At each of the bridge locations, provisions were considered for the inclusion of lighting, utilities, and a solar array canopy including:

- Bridge lighting can be provided using traffic-barrier-mounted light poles, consistent with approach roadway lighting. Provisions (e.g., conduits and mounting hardware) could be included in the initial construction to minimise future modifications.
- Utility installations would vary depending on the type of utility, with options including:
  - Buried facilities,
  - Utility conduits in bridge traffic barriers,
  - Deck-mounted utility hangers,
  - Utility supports attached to the outside of bridge barriers.
- For the solar array canopy, it was assumed that the array would terminate at each end of the bridge to avoid imposing substantial wind loads on the bridge itself.

The appropriate solution for utility crossings will be determined during the subsequent design phases when more detailed geotechnical and survey information becomes available.

Overall, the utility design aims to balance present needs with future demand, ensuring minimal disruption, resiliency, and the ability to adapt as the region grows and infrastructure needs evolve. Dedicated utility corridors have been identified within the overall project corridor to provide ample space for accessibility as well as providing for reasonable clearance from other design elements such as pavement and barrier. The final location of the utility corridors will be confirmed in a later stage of the design process.

Another CSF of the project is to establish accommodations for utility expansion (electricity, fibre, water, central sewage), which is met through providing dedicated area, or utility corridors, within the project's footprint.

6.6.11.6 Highway Lighting Placement

The design of the Proposed Project includes the strategic placement of highway lighting along the corridor, focused on phased implementation for safety and visibility, while also minimising environmental impacts in sensitive areas. It is recommended that lighting be installed in critical locations, beginning in the initial build year of 2026, and expanded as the Proposed Project develops and traffic volumes increase. Key locations for highway lighting include:

- Major intersections, such as the Woodland Drive/Agricola Drive and Frank Sound Road intersections, where higher traffic volumes and complex turning movements necessitate enhanced visibility for vehicles, pedestrians, and cyclists.
- Roundabouts and RCUT intersections, where multiple lane changes, turning movements, and pedestrian activity require clear illumination for safe navigation.
- Residential and commercial zones along developed sections, where lighting will support night-time travel safety for vehicles, pedestrians, and micromobility users.
- Bridges and hydraulic structures, to provide adequate lighting for both vehicular and non-motorized traffic crossing water bodies or other structural openings, ensuring safety during inclement weather or low visibility conditions.

The inclusion of lighting would be phased based on traffic demand and development progression. Initially, lighting would focus on high-traffic intersections and key areas near existing development. Additional lighting along the corridor, including in more developed sections and along bridges, will be phased in as needed to align with the introduction of new lanes, a sidewalk, and a micromobility path.

As future phases are constructed (e.g., additional travel lanes, transit lanes, etc.), lighting would be extended to accommodate these new elements. A discussion on environmental factors and risks to consider as they relate to highway lighting is further discussed in **Section 6.8.8: Risk Management and Contingency Plans** and **Section 6.10.1: Environmental Impact Mitigation**.

6.6.12 Solar Array

A preliminary assessment for a solar photovoltaic (PV) canopy/array was conducted for each of the shortlisted alternatives, including the Proposed Project, and is detailed in **Appendix F.6: Solar Array Memo**. The analysis provides estimates for the PV system size, a Class 5 cost estimate (with a variance of +/- 30%), and an energy production forecast. A Class 5 estimate is used for high-level and more limited detail cost estimates.

The solar panel canopy/array was evaluated over a 6 mi (9.6 km) section of the Proposed Project. The conceptual design features a 40 ft (12.2 m) wide array of solar panels located above the micromobility path and sidewalk. This placement maximizes the use of available space while providing renewable energy benefits to the corridor. Note that implementation of the solar array is outside of the ambit of the NRA. The NRA will provide the ability for the corridor to accommodate this feature.

6.6.12.1 Cost and Energy Estimates:

- **Capital Expenditure (CAPEX)**: The estimated cost to build the system is approximately $65.65 million CI ($78.15 million USD), with a Class 5 estimate accuracy of +/- 30%**.**
- **Operational Expenditure (OPEX)**: The annual operating cost is estimated at $319,369 CI ($380,201 USD).
- **Energy Production**: The 22.23-megawatt (MW) solar array is expected to generate enough energy to significantly reduce carbon emissions. Over a 30-year period, it could offset approximately 703,556 tons of CO2.
- **Fuel Savings**: Based on 2016 electricity consumption data from WorldMeters.info for the Cayman Islands, the solar array would save approximately 2,556,400 gallons (9,677,026 litres) of diesel fuel per year.
- **Energy Supply**: The solar array would provide approximately 5.6% of the Cayman Islands' annual electricity demand, contributing to the island's energy independence and sustainability goals.

6.6.13 Transit Overview

Implementation of public transit is outside of the ambit of the NRA. The NRA will provide the ability for the corridor to accommodate these features. Public transit services in Grand Cayman are managed by the Public Transport Unit under the Ministry of Planning, Agriculture, Housing, Infrastructure, Transport & Development (PAHI-TD Ministry). The Public Transport Board directs this unit and oversees the issuance of permits for public passenger vehicles as well as the safety and staffing of public transport services.

6.6.13.1 Current Transit Routes

Currently, twelve public bus routes serve key areas across the island, including West Bay, George Town, Bodden Town, North Side, and East End. All routes begin and end at the bus depot on Edward Street in George Town. The routes are numbered and named, with descriptions provided in **Table 6-18**.

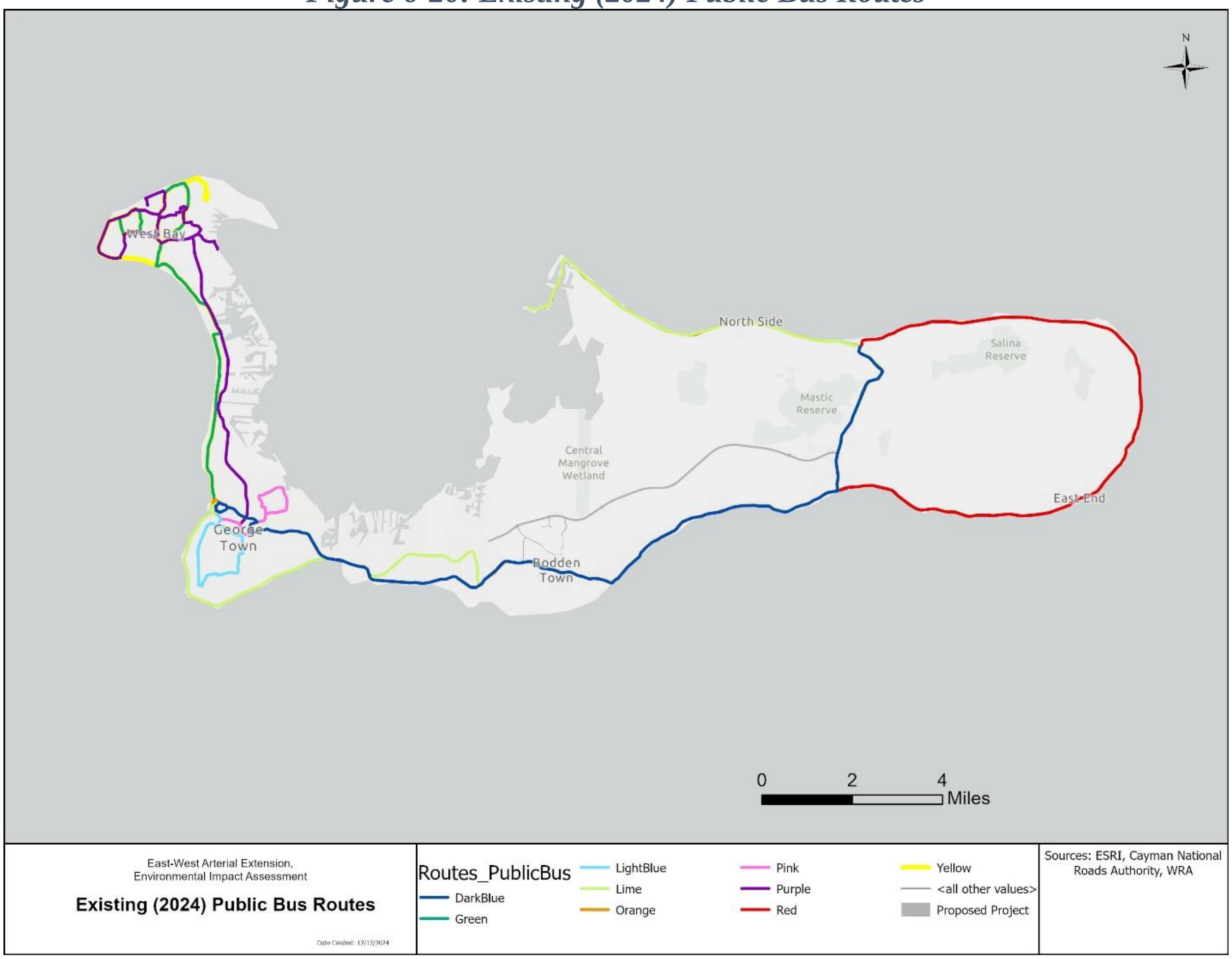
Table 6-18: Existing Public Bus Routes

Route Number	Name	Description
1WB	Yellow	From bus depot north to West Bay, serving West Bay Road, Hell, Cayman Turtle Centre, and Governor’s Residence.
2WB	Green	From bus depot north to West Bay along West Bay Road with different routing in West Bay than route 1.
3WB	Purple	From bus depot north to West Bay along Esterley Tibbetts Highway, connecting to airport
4B	Bright Blue	From bus depot circulating through central George Town, connecting to Government Hospital, Sports Complex, and University College
5A	Pink	From bus depot to airport
5B	Pink	From bus depot to airport
7A	Red	From bus depot to East End via Crewe Road, Shamrock Road, passing through Bodden Town
7B	Lime	From bus depot to East End, but first serving South Sound Road past Smith Cove rather than Crewe Road (route 7A)

Route Number	Name	Description
8A	Orange	From bus depot to North Side via Crewe Road, Shamrock Road (not serving East End)
8B	Lime	From bus depot to North Side via South Sound Road (rather than Crewe Road), EWA
9A	Dark Blue	From bus depot to North Side around Queens Highway through East End
9B	Lime	From bus depot to North Side first serving South Sound Road, Shamrock Road, around Queens Highway through East End

These routes are shown in **Figure 6-20** along with the locations of the Proposed Project.

Figure 6-20: Existing (2024) Public Bus Routes



6.6.13.2 Strategic Plans and Future Transit Vision

The Public Transport Board has outlined both a five-year Strategic Plan and a Public Transport Strategy (adopted in 2022) to guide the future of transit on the island. These plans focus on improving service delivery, reducing emissions, and enhancing the overall transit experience.

Key goals of the five-year Strategic Plan:

1. Governance
2. Strategic & Future Planning
3. Education & Training
4. Human & Financial Resources
5. Internal Stakeholder Engagement
6. External Community Engagement
7. Innovation

Strategic priorities from the Public Transport Strategy (LTCT-PTU2022-001 by Deloitte) include:

1. Increase utilisation of transit services (e.g., improve vehicle capacity, add dedicated transit lanes).
2. Improve customer experience (e.g., add bus stops with shelters, enhance amenities).
3. Enhance human resources for better service delivery.
4. Reduce emissions by transitioning to electric vehicles.
5. Strengthen organizational efficiencies in the transport system.

6.6.13.3 Potential Transit Features for the Proposed Project

The Proposed Project offers opportunities to improve public transit by incorporating modern infrastructure and services that complement existing services while also aligning with the island's sustainability goals. Proposed features include:

- Modification or addition of bus routes to serve the Proposed Project corridor.
- Bus stops and shelters along the bus route, with adequate pedestrian crosswalks for safe access.
- Transit customer amenities such as:
    - Shelters with solar-powered lights.
    - Rider information displays showing routes, schedules, and real-time bus arrivals.
    - Battery-electric vehicles and supporting infrastructure, such as depot and on-route charging stations.

The following sections describe the proposed transit services and infrastructure for buildout of the Proposed Project. Proposed transit service for just the first phase of the Proposed Project is also discussed within this section under Phasing of Transit Infrastructure and Services.

6.6.13.4 Modification or Addition of Bus Routes

The Proposed Project provides flexibility in meeting the provision for transit elements and services. Depending on the PAHI-TD Ministry’s objectives for the frequency of transit service, the following options are available:

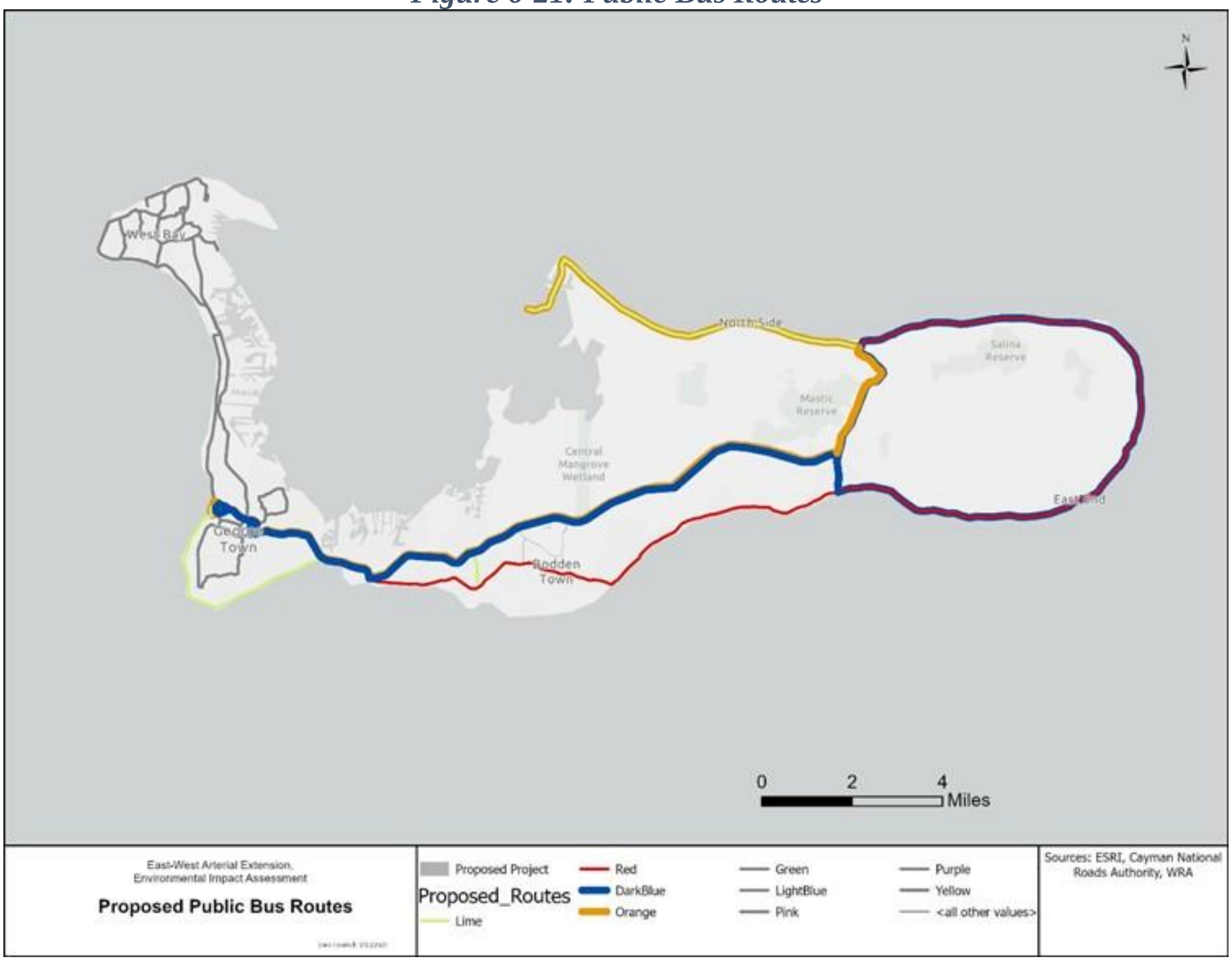
- New transit routes could be introduced to serve destinations along the Proposed Project.
- Existing routes could be modified to better serve the Proposed Project and improve overall connectivity.

This analysis anticipates a scenario where two of the existing routes serving the east end of the island are relocated to utilise and serve the EWA. Specifically:

- **Figure 6-21** proposes modifying the Orange and Dark Blue routes to better serve the Proposed Project corridor.
- Currently, all routes to Bodden Town and East End travel along Shamrock Road.
- By relocating the Orange and Dark Blue routes, four other routes would continue to serve Shamrock Road, ensuring service to both the Proposed Project and the Shamrock Road corridor.

This modification aligns with the goals of optimizing transit service coverage across the island, especially in response to the new transportation infrastructure provided by the Proposed Project.

Figure 6-21: Public Bus Routes



6.6.13.5 Bus Stops and Shelters

The addition of transit service along the Proposed Project would require the installation of new bus stops and shelters to accommodate passengers. New stops and shelters may be constructed similarly to existing bus shelters as illustrated in **Figure 6-22**. As outlined in **Table 6-19**, bus stops and shelters are recommended on both sides of the roadway in the four-lane sections, with two stops and shelters at each location.

Figure 6-22: A Typical Grand Cayman Bus Stop

Source: signsolutions.ky

A preliminary assessment of the potential locations and number of stops and shelters was completed to estimate the order-of-magnitude costs of transit elements. The exact shelter locations should be coordinated as part of the detailed design phase to allow for optimal placement and accessibility. To provide for pedestrian safety, crosswalks will likely be necessary at each bus stop to allow safe crossings of the divided roadway.

Figure 6-23 shows existing bus stops in the vicinity of Sections 1 and 2, along with preliminary locations for new stops based on nearby intersections, neighbourhoods, and other destinations. In total, five locations were identified, with each having two stops and two shelters, resulting in a total of 10 bus stops and shelters for these sections.

Table 6-19: Bus Stops and Shelters

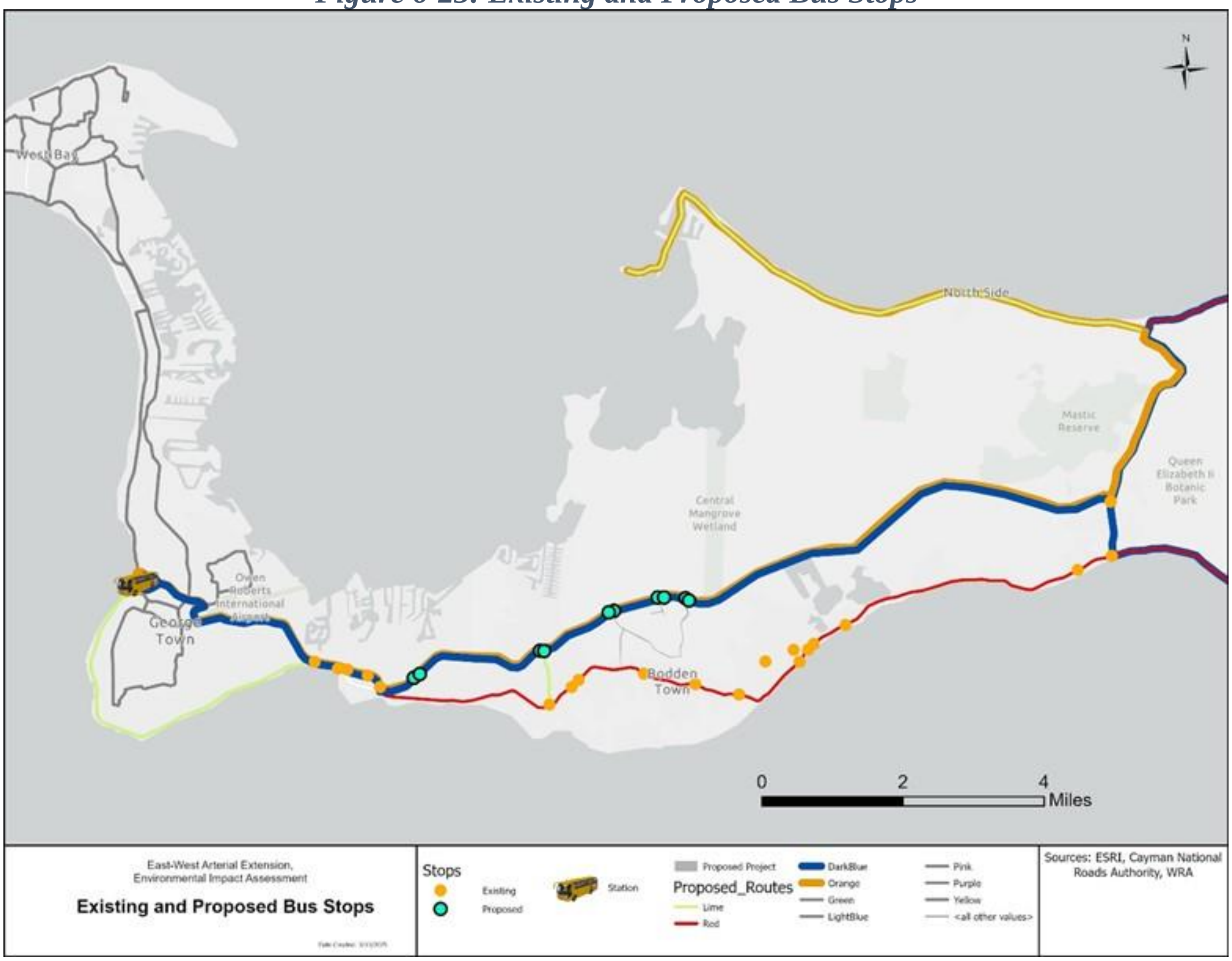
Section	Number of Bus Stops with Shelters	Estimated Cost CI$ (USD)
1 and 2	10	**$210,000** ($250,000)
3	14	**$294,000** ($350,000)
Total	**24**	**$504,000** ($600,000)

The construction cost of a bus stop with a shelter is estimated to range between $12,600 and $63,000 CI (equivalent to $15,000 - $75,000 USD) per location, depending on the level of customization and customer amenities included. Potential bus shelter amenities may include:

- Benches
- Trash bins
- Lighting
- Wi-Fi and Charge Station
- Rider information, such as static route maps or real-time arrival information

For the purposes of this analysis, a standard cost of $21,000 CI ($25,000 USD) per location was used. The total number of stops and shelters is based on the identified locations in **Figure 6-23**, plus an additional four shelters to account for planned developments near Lookout Road.

Figure 6-23: Existing and Proposed Bus Stops



6.6.13.6 Transit Customer Amenities

As highlighted in the previous section, there are several transit customer amenities that could be integrated into the Proposed Project to enhance the passenger experience (**Figures 6-24** and **6-25**). Some practical and effective amenities to consider for new stops and shelters include:

- **Covered shelters** with lighting and rider information.
- **Modern LED lighting**, which uses significantly less electricity than older lighting technologies and can even be solar-powered.
- **Roof-mounted solar panels** with batteries, extending the availability of lighting late into the night.

The solar array discussed earlier in this chapter is a potential energy source for powering shelter lights and real-time rider information displays, making the transit infrastructure more sustainable.

At a minimum, transit shelters should provide:

- Bus route information
- Schedules of services

To further improve the rider experience, a possible feature that is recommended is electronic, real-time rider information be included. These "smart" shelters can:

- Display the location of the next bus.
- Provide the predicted arrival time, offering valuable information to waiting passengers.

By integrating these features, the transit shelters would not only improve convenience but also support the shift toward sustainable energy solutions and smart infrastructure.

Figure 6-24: Example of a Public Bus Stop with an Electronic Schedule Display

Source: TourDigital

Figure 6-25: Example of a Public Bus Stop with Safety Lighting

Source: Handi-Hut.com

6.6.13.7 Planning for Clean and Sustainable Transit

The transit service planned for the new Proposed Project offers a valuable opportunity to advance the Public Transport Board's vision for a clean, efficient, and sustainable public transportation system. In addition to solar-powered lights and rider information electronics, consideration should also be given to the future use of battery-electric vehicles (BEVs).

Recent advancements in the below have contributed to the growing adoption of battery-electric buses in transit systems worldwide (Federal Transit Administration (FTA) Report No. 0253 – Procuring and Maintaining Battery Electric Buses and Charging Systems – Best Practices):

- Battery technology
- Charging systems
- Electric grid resiliency
- Operational planning

<u>Battery Electric Vehicle Considerations</u>

Implementing battery-electric transit vehicles in the Proposed Project requires careful system planning to address key factors such as:

- Range requirements for daily operation.
- Recharging needs for the vehicles during service hours.

Fortunately, Grand Cayman's climate, flat terrain, and relatively short route distances make it an ideal candidate for using battery-electric buses or vans. While battery-electric buses may not be suitable for regions with cold weather, hilly terrain, or long-distance routes, the conditions in Grand Cayman are well-suited to the technology.

Charging Solutions

While depot-charging (charging buses at a central depot) may be a sufficient solution for some routes, longer routes on the Proposed Project to East End and North Side should consider on-route quick charging to maintain operational efficiency (**Figures 6-26** and **6-27**). Quick-charging systems can restore most of a vehicle's battery charge much faster than traditional depot charging, ensuring that buses can stay in service for longer periods.

Ideally, battery-electric vehicles would recharge at both ends of their route:

- At the bus depot in George Town.
- At an end-of-the-line station on the east end of the island.

By incorporating on-route quick charging, the system can provide seamless operation without requiring long downtime for recharging.

Battery Electric Bus (BEB) Charging
1 BEB range can vary from less than 100 miles (161 km) to over 200 miles (322 km) depending on the size of the battery pack and many operating variables (terrain, temperature, use of on-board air conditioning, etc.). So, careful planning is required to match vehicle capabilities with the operating expectations, considering the length of bus routes, daily hours of service, and hours of downtime for charging.
2 Depot charging can typically provide 40-125 kW and charge time may vary between 1-8 hours.
3 On-route fast charging may deliver higher power (125-500 kW) with reduced charge time of 5-20 minutes per charge. On-route charging may allow the use of vehicles with small onboard batteries and allow vehicles to remain in service for an entire day. Planning is necessary, however, so that vehicle dwell time at an on-route charger (typically at an end-of-the-line station) is adequate to replenish the batteries.
4 Regardless of the charging strategy, system planning should also consider back-up charging in the event of a wide-spread power outage.

Figure 6-26: Example of Typical Bus Depot Charging

Source: EVSE Australia

Figure 6-27: Example of On-Route Quick Charging

Source: USDOT

6.6.13.8 Phasing of Transit Infrastructure and Services

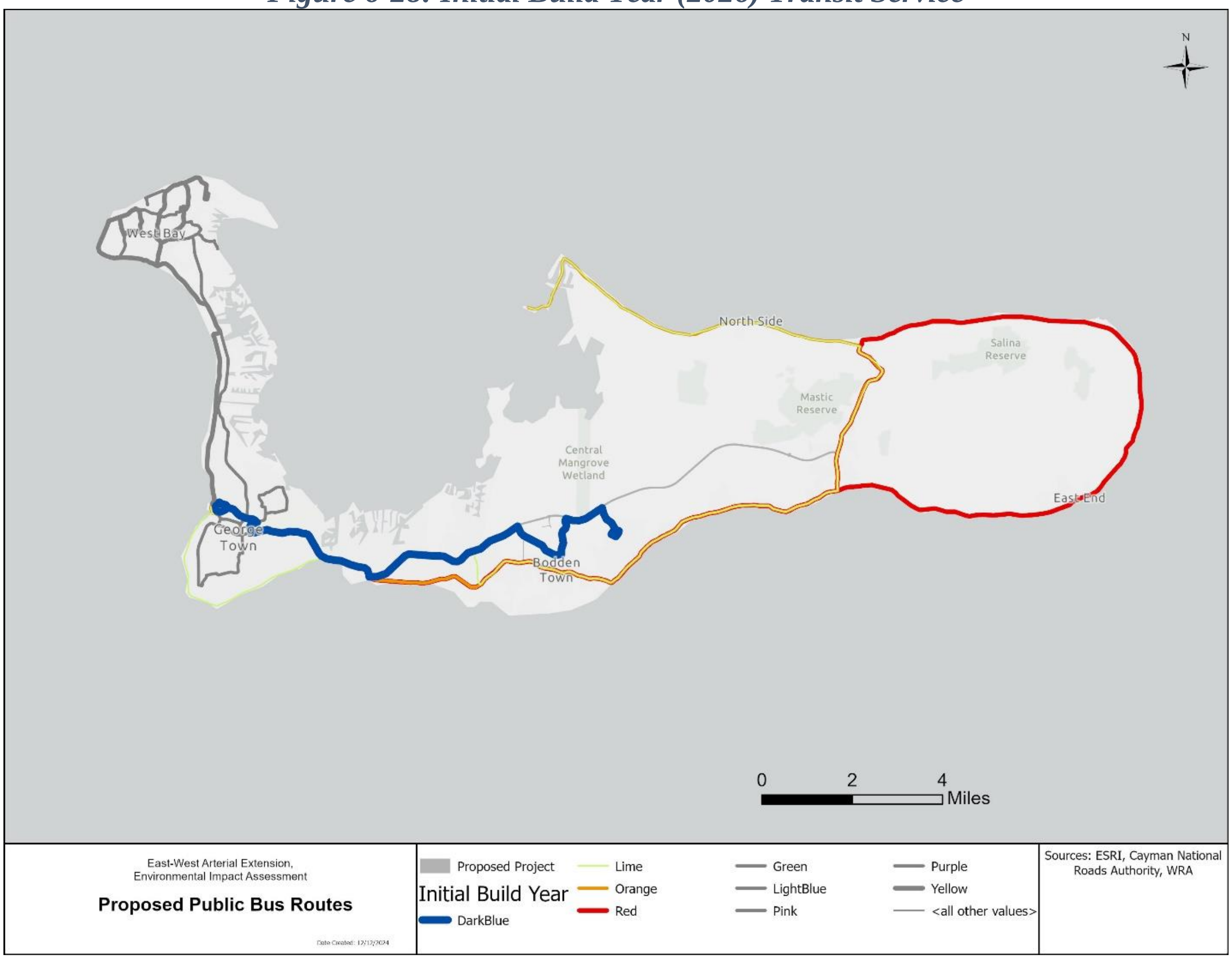
The preceding sections discuss the proposed transit systems and services for full buildout (2074) of the Proposed Project. How and when these services are phased into service depends on the construction phasing of the Proposed Project, coordination with the transit operators, timing of construction of connecting streets, timing of new development and other factors.

It is proposed that the initial build year (2026) of the Proposed Project be complimented with an initial transit service which includes:

- Modify the existing Dark Blue route to travel along the East-West Corridor to the Will T connector and to Lookout Road.
- Create bus stops on Will T and on Lookout Road
- No new bus stops or features on the initial phase of the Proposed Project. Stops would be located along Will T Connector and along Lookout Road.
- Other existing bus routes will continue to operate as they do today.

The proposed initial build year bus routes are illustrated below on **Figure 6-28**.

Figure 6-28: Initial Build Year (2026) Transit Service



6.7 Right-of-Way (ROW) and Acquisition

The Proposed Project will impact land parcels along the entire length of the proposed facility. In some cases, this will result in a partial take, where only a portion of the property is impacted and purchased, while in other instances, a full taking will be necessary, requiring the acquisition of the entire parcel. **Table 6-20** provides a summary of the estimated total acreage affected by the Proposed Project, and a more detailed breakdown of the impacts is included in **Appendix F.8:**

Parcel Impacts and Costs. The monetary costs associated with these acquisitions and any necessary relocations are discussed in **Section 6.2.2: Right of Way (ROW) Cost Estimate**.

In certain cases, structures located on impacted parcels will affect the overall cost of property acquisition, which includes both the purchase price and demolition costs. **Table 6-21** summarizes how the Proposed Project is expected to impact residential, commercial, and emergency service building structures.

The ROW acquisition needs for the Proposed Project have been slightly modified from the shortlisted Alternative B3 due to the altered footprint at the intersection locations related to the change in intersection design.

Table 6-20: Summary of Parcel Impacts for Proposed Project

Total Impact Area Acres (Hectare)
249.14 ac (100.86 ha)

Table 6-21: Structural (Building) Acquisitions for Proposed Project

Structure Type	Number of Structures
Residential Building Structures	2
Commercial Building Structures	0
Emergency Building Structures	1
Total Structure Impacts	**3**

6.8 Phasing and Constructability

6.8.1 Phasing

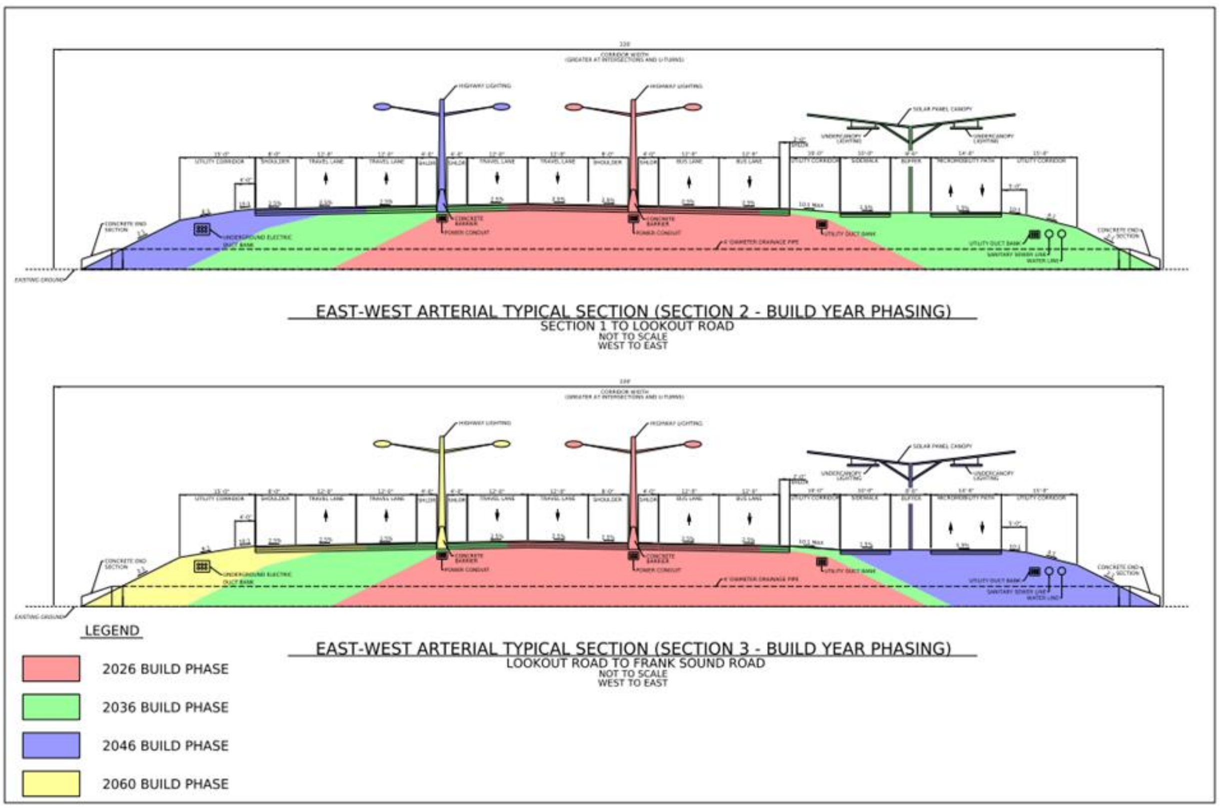
The phasing of the construction timeline for the Proposed Project, which spans from 2026 to 2060, has been carefully designed to minimise environmental impact and optimize the placement of features within the Proposed Project corridor. The timeline for introducing and placing the various features was developed with a focus on managing the overall footprint of the corridor and to best minimise impact to the areas north of the corridor.

As part of the conceptual design the overall corridor construction phasing was examined with the goal to begin the initial construction of the Proposed Project along the southern limits of the corridor and to delay impacts to the northern part of the corridor for as long as possible. This approach aims to allow for maintaining the natural state of the environment along the northern limits of the corridor. Therefore, the initial build year of 2026 will focus on constructing the typical section along the southern limits of the corridor, so that the initial disturbance remains concentrated away from the northern limits of the corridor until determined necessary.

Future build year features will be expanded from this southern initial build area of the corridor, progressively moving northward. The northernmost features will be implemented during the latest possible build years, with the addition of two travel lanes and a utility corridor planned for 2046 in Section 2 and for 2060 in Section 3. Lighting installations will follow this pattern, with environmentally sensitive areas, such as the CMW, receiving minimal lighting to avoid disrupting wildlife and reduce light pollution.

This phased approach to construction and development is both fiscally and environmentally prudent by not building or impacting more than necessary. It also allows the project to adapt to changes in demand due to population growth or developments while also allowing lessons learned from prior phases, new mitigation technology, or approaches for mitigation to be deployed during subsequent phases of construction. A graphic depicting the overall footprint of each phase of the build year for Section 2 and Section 3 can be seen in **Figure 6-29** below. A larger version of this figure can be found in **Appendix F.11: Corridor Phasing Coloured Typical Section.**

Figure 6-29: Build Year Phasing



6.8.2 Constructability Considerations

Constructability refers to the ease of construction and the time, effort, and complexity involved in executing the project. Several environmental factors significantly impact the constructability of the Proposed Project. The proposed corridor is located in a remote part of the island, with limited established access points, presenting logistical challenges for material and equipment transport. Additionally, the corridor traverses areas with mangroves, wetted regions, and sections of peat—an organic, unstable material that varies in size and depth throughout the corridor.

6.8.2.1 Temporary Access Points

To facilitate construction along the Proposed Project corridor, temporary access points will have to be established. Given the remote nature of the site and the linear construction requirements, primary access points will come from existing public cross-roads such as areas adjacent to the Will

T Connector, Lookout Road, and other unmarked vehicle paths and trails. Construction will begin from these locations with work progressing toward the interior of the corridor. Temporary access agreements will also have to be sought with private landowners to establish additional access points.

6.8.2.2 Peat Removal and Subgrade Stabilization

To provide for the stability of the roadway embankment in areas where peat is present, special measures are recommended to be taken, including peat removal. This process involves excavating the peat and replacing it with stabilized subgrade material. Excavation will be carefully and slowly executed to ensure the necessary peat is removed, which is labour-intensive due to the volume of material involved. After excavation, the voids will be filled with subgrade material that would be laid and compacted. Given that many of these areas throughout the Proposed Project corridor are located in heavily vegetated and wetted environments, access roads for construction equipment and personnel will need to be built and maintained throughout the project.

Another approach to reducing the construction timeline and costs is the use of geotechnical solutions, such as geogrids or open cellular foundation mattress systems, which could possibly be installed over the peat without removal. These solutions could potentially accelerate the construction process and lower costs. However, additional geotechnical evaluation is required to assess the feasibility of these alternatives. For the purposes of this EIA, it is assumed that the peat will be fully removed.

6.8.2.3 Bulk Earthwork Operations

Bulk earthwork operations will involve importing significant quantities of fill material to establish the proper roadway grade for embankment areas. In areas requiring deep fills, geotextiles or geogrid materials may be used to stabilize the ground before placing additional fill layers. The sequence of bulk fill operations will be guided by access to quarry areas and preliminary erosion and sedimentation controls. Earthwork will be phased so that stormwater and sediment control measures are in place before proceeding with additional construction.

6.8.2.4 Weather Considerations

Weather conditions—such as the rainy season or the potential for hurricanes—could disrupt construction timelines, particularly in sensitive areas. It is recommended that temporary stormwater management plans as well as contingency plans be established to mitigate delays caused by weather and extreme event, including procedures for protecting critical work areas during adverse conditions.

6.8.3 Material Sourcing, Transportation and Earthwork

Given the remote nature of the Proposed Project site, sourcing and transporting construction materials will present logistical challenges. Large quantities of subgrade material for peat replacement and embankment construction will need to be imported from the off-site authorized commercial quarries that are present in the project area. The aggregate quantities for the Proposed Project require an estimated maximum of 10-15% of the available within authorized commercial quarries (see **Section 11.2.5: Quarries** for more details). Therefore, it is assumed that all aggregate materials would be acquired from authorized commercial quarries. The bulk of this material will be required to establish the appropriate roadway grade for embankments, as well as for other construction needs such as pipes, culverts, and bridge abutments.

6.8.3.1 Material Sourcing

Imported fill materials used for embankment construction should be clean and free of contaminants. Additionally, the materials used in construction, including aggregates for bridge lifts and stabilization, will need to be sourced with contingency planning in mind. Multiple suppliers should be identified to provide for redundancy and avoid supply chain disruptions, especially for critical materials like structural steel, drainage pipes, and specialized highway lighting components.

6.8.3.2 Earthwork Operations

Bulk earthwork operations will be sequenced according to access routes from quarries, the location of on-site fills, and pre-construction activities such as sediment and erosion control installations. In areas where the final subgrade is to be more than 5 ft (1.5 m) above existing ground, bridge lifts will be utilised to stabilize the existing soil. These lifts, typically composed of aggregate or similar materials, will allow for subsequent layers of fill to be placed and compacted in dry conditions. Geotextile fabrics or geogrids may be used to further stabilize the ground in areas where the existing soils are less suitable for fill placement.

For areas of shallower fills, grubbing and topsoil stripping will be necessary before fill operations can begin. In areas requiring additional stability, ground improvements such as undercutting, or the use of geotechnical solutions may be implemented. Once stripped, topsoil can be stockpiled for reuse on the project.

6.8.3.3 Transportation and Logistics

It is recommended that a transportation plan be developed to provide for efficient delivery of materials from existing quarries to the construction site. The long, narrow construction corridor, combined with the limited established access points, presents a logistical challenge. Primary access points will likely be off of existing public roads such as the Will T Connector area, with additional access established through temporary agreements with private landowners where feasible.

Given the remote nature of the site, special attention should be given to reducing travel distances by identifying potential local sources for construction materials. Furthermore, contingency plans for supply chain risks, such as delayed shipments or material shortages, should include securing backup suppliers and stockpiling critical materials.

Temporary access roads within the corridor limits may need to be constructed to facilitate the movement of materials, and temporary crossings of wetlands and other sensitive areas should be minimised and closely monitored. BMPs such as geotextile fabric, equipment mats, or prefabricated pads will be utilised to protect the natural environment during these activities.

6.8.3.4 Environmental Considerations for Earthwork and Transportation

It is recommended that during earthwork and material transportation operations, stringent environmental protection measures be defined and enforced. These measures, in general, include the use of sediment control facilities to manage runoff and prevent sediment-laden water from leaving the project site. Similarly, efforts should be made to prevent off-site waters and runoff from entering unstabilised areas.

6.8.4 Workforce Management and Safety

Workforce logistics should be carefully managed, considering the remote and environmentally sensitive nature of the corridor. Due to limited access points, strategically placed workforce accommodations will be necessary to reduce travel time to construction areas. These accommodations will be located within the gazetted corridor to streamline operations and to provide for rapid access to active construction zones.

It is recommended that emergency response plans be established for the entire project site, with protocols in place for worker safety and rapid response in case of accidents, especially in areas where the terrain or working conditions pose higher risks, such as in peat excavation zones or where hazardous materials might be present. Workers will be trained in emergency response procedures, including protocols specific to wildlife encounters or environmental accidents.

Environmental protocols should be strictly enforced to protect identified wetlands, wildlife habitats, and other sensitive areas. This includes clear demarcation of non-impacted zones and areas where heavy machinery is prohibited. It is recommended that flagging and protective measures be employed to prevent accidental encroachment into environmentally sensitive areas.

Safety protocols will be prioritized in areas requiring specialized construction methods, such as peat excavation, geotechnical stabilization, or the installation of work zone lighting in low-visibility zones. These areas will require additional worker training and the use of temporary lighting or other visibility aids to enhance safety during night shifts or in poor weather conditions.

By addressing these critical safety and workforce management concerns, the project will maintain high operational efficiency through the protection of both workers and the surrounding environment.

6.8.5 Environmental Protection During Construction

Given the sensitive environmental features along the Proposed Project, such as mangrove wetlands and wildlife habitats, the use of environmental protection measures will be critical throughout the construction process. The NRA and detailed design team is aiming to provide environmental protection measures where possible. Strict adherence to environmental commitments and mitigation measures should be enforced during the construction phases of the Proposed Project once detailed design identifies project specifics. This will likely include erosion and sediment control (E&S) measures and temporary wetland protection strategies to safeguard natural habitats.

Before the start of construction in any specific area, flagging or demarcating non-impacted wetlands and upland buffers should occur so that these sensitive areas remain undisturbed. These flagged areas can remain marked for the entire duration of construction activities, with no work permitted in these zones. Upon completion of construction in a particular area, final stabilization will be achieved, in providing that soils are stabilized and revegetated before E&S controls are removed.

Regular inspections and maintenance of the E&S controls should be conducted to reduce impacts on surface waters and to protect wildlife habitats, including special species habitats. This proactive approach is recommended so that potential runoff or erosion issues are mitigated, preventing sediment from entering wetlands, streams, or other ecologically sensitive zones.

Temporary construction activities within wetlands, such as access roads or utility crossings, should follow best management practices (BMPs). These activities may require the use of geotextile fabric, equipment mats, or prefabricated pads to protect the root structure of sensitive vegetation. Upon completion of these temporary activities, wetlands will be restored to pre-construction contours, with the soil decompacted and vegetation restored so that the natural hydrology and ecology are re-established.

Additionally, a spill prevention plan can be developed and strictly enforced for the hazardous materials used during construction. This plan should include procedures for the proper storage, handling, and disposal of hazardous substances for compliance with environmental standards and lower the risk of spills affecting wetlands or other sensitive areas. The construction plans should incorporate clearly defined wetland delineation boundaries and include environmentally focused special technical provisions to safeguard sensitive wetland habitats and the wildlife that depend on them.

By implementing these comprehensive environmental protection strategies, the project will have minimal disruption to the surrounding ecosystems while maintaining compliance with local and international environmental standards.

6.8.6 Phased Construction and Rebuilds

Due to the phased construction timeline, certain features of the Proposed Project will need to be reconstructed as new phases are implemented. Since the initial build year (2026) will focus on constructing the southern portion of the corridor, future phases will require adjustments to these earlier sections. For example, when transit lanes are added in 2036 and the travel lanes are shifted northward, turn lanes, curbing, traffic separators, and intersection tie-ins will need to be rebuilt. Additional features, such as median barriers, guardrails, highway lighting, and pavement transitions, may also need to be adjusted.

6.8.7 Space for Construction Staging

It is estimated that the initial phases of construction would offer the necessary space within the Proposed Project corridor for haul roads, stockpiles, and equipment storage. Potential locations for these operations have been identified in **Appendix F.9: Preliminary Material Stockpiling and Equipment Storage Locations**, with selections made to avoid environmentally sensitive areas including mangroves, wetlands, parrot habitats, and peat zones. However, as future build years progress, available space within the Proposed Project corridor will become more limited. Future construction may require the use of traffic control measures to manage space requirements on previously built sections. The contractor should, wherever feasible, use the Proposed Project alignment for haul road placement to lessen environmental impacts.

As more features are constructed, the need for staging equipment and materials outside the corridor may arise, particularly in later phases. Future development in the area could influence the suitability of current staging locations, so ongoing assessments will be necessary as the project advances.

6.8.8 Risk Management and Contingency Plans

Given the complexity of the Proposed Project, the need for specialized construction methods, and the potential for unforeseen challenges, a robust risk management plan is essential for project success. This plan will focus on mitigating risks related to cost overruns, schedule delays, and unexpected engineering challenges during construction. Key risks should be regularly monitored, and contingency plans be activated as necessary to keep the project on track.

6.8.8.1 Identified Key Risks

- **Geotechnical Challenges**: The presence of peat in various locations poses significant risks to construction timelines and costs. Deeper or more widespread peat layers than anticipated may necessitate additional excavation, stabilization, or alternative construction methods.
- **Environmental Factors**: Potential weather delays from tropical storms or heavy rainfall events could impact construction schedules. Additionally, unexpected impacts to wetlands, wildlife habitats, or other environmentally sensitive areas may delay permits or require additional mitigation efforts. Extreme weather events, such as tropical storms or hurricanes, may affect the construction and maintenance of highway infrastructure, especially in flood-prone areas and include, but is not limited to highway lighting, sign structures, traffic signal equipment, above other ground utilities.
- **Supply Chain Disruptions**: Material shortages or delayed shipments, especially for specialized construction materials (e.g., structural steel, drainage pipes, or imported fill materials), could cause interruptions.
- **Contractor Coordination**: Multiple contractors and subcontractors working simultaneously could create coordination challenges, leading to inefficiencies or schedule delays if not properly managed.
- **Cost Overruns**: Unanticipated cost escalations for labour, fuel, or materials (particularly for imported items) may affect the project's budget. Global supply chain disruptions or local market conditions could exacerbate these risks.
- **Highway Lighting Placement**: The installation of highway lighting, particularly in environmentally sensitive areas such as the CMW and parrot habitats, presents a risk of light pollution and disruption to wildlife if not carefully planned and executed. The NRA is striving to implement lighting that is properly designed and placed in critical areas (e.g., major intersections, bridges, and developed sections) while minimising impacts to natural areas is crucial for project success.

6.8.8.2 Contingency Plans

- **Geotechnical Risk Mitigation**:
  - Conduct additional geotechnical investigations in the final design phase to better understand the extent of peat layers and other subsurface conditions. If deeper peat layers are discovered, geotechnical stabilization methods (such as geogrids or open cellular foundation mattress systems) should be evaluated to reduce the need for full peat removal.
  - Develop contingency plans for alternative excavation methods or stabilization techniques if peat removal becomes too time-consuming or costly.
- **Stormwater Management**:
  - Additional hydraulic and hydrologic study will necessitate the establishment of a Stormwater Management Plan to protect existing development and preserve the integrity of the surrounding environment.
- **Weather and Environmental Risk Mitigation**:
  - Establish a detailed weather monitoring program during construction to anticipate potential weather delays and proactively adjust the schedule.
  - Implement environmental monitoring during construction for compliance with permits and enable early identification of impacts to wetlands, habitats, or cultural resources, preventing costly stop-work orders.

    - For highway lighting, develop a strategy to minimise light pollution in sensitive areas (e.g., the CMW) while ensuring safety at key intersections and developed zones. Temporary lighting solutions may be necessary during construction to provide visibility without permanently affecting wildlife. Build flexibility into the construction schedule, allowing for time contingencies during the rainy season or peak storm periods.
- **Supply Chain and Material Risks**:
    - Advance procurement of critical materials, particularly those susceptible to supply chain disruptions (e.g., drainage systems, concrete, steel, and highway lighting components) to reduce risk.
    - Develop relationships with multiple suppliers to provide for redundancy in the event of material shortages or delays.
    - Include a buffer in the project timeline for potential shipping delays, especially for imported materials.
- **Highway Lighting Risk Mitigation**:
    - Early procurement of low-light pollution lighting fixtures or solar-powered alternatives to provide availability for sensitive areas such as wetlands or wildlife habitats.
    - Coordinate with utility providers for the timely installation of electrical connections for highway lighting, particularly in critical zones like intersections and bridges.
    - Establish backup plans for lighting installations in sensitive areas, such as temporary solar-powered lights or systems that lessen disruption to local wildlife during construction and operation.
- **Contractor and Subcontractor Coordination**:
    - Provide a well-defined construction management plan with clear communication protocols between contractors and subcontractors. Regular coordination meetings will be necessary to engage the necessary parties on schedule and potential risks.
    - Employ on-site project managers to oversee and resolve coordination issues in real-time.
- **Cost Overrun Mitigation**:
    - Establish a contingency budget specifically for unexpected cost increases in materials, labour, or fuel prices. This should be included in the overall project budget as a buffer for unanticipated expenses.
    - Re-evaluate material options during the final design phase to explore cost-saving alternatives that maintain safety and durability, such as sourcing local materials or using prefabricated components where feasible.
    - Maintain open lines of communication with suppliers and review contracts to have clear terms on price escalations.

6.8.8.3 Risk Monitoring and Reporting

- **Project Risk Management Plan:** A developed plan to monitor project risks in different sectors including a project risk register that provides a continuous document for identifying and mitigating risk as the project progresses.
- **Construction Monitoring Protocols**: Continuous monitoring of construction activities for adherence to environmental commitments and safety standards throughout the project. Regular site inspections for compliance with erosion and sediment control (E&S) measures, protection of sensitive environmental areas, and health and safety protocols will

be conducted. These inspections will be documented in monthly reports, and corrective actions will be logged for any non-compliance issues.

- **Reporting Frequency**: Contractors and environmental compliance officers will submit weekly updates on construction progress, environmental protection efforts, and any risks encountered. A monthly risk review meeting will take place with key stakeholders to evaluate any issues and implement mitigation strategies as needed. Detailed progress reports will be shared with the oversight team, ensuring that real-time decisions can be made based on updated risk assessments and construction milestones.
- **Environmental Reporting**: Regular reporting of environmental monitoring activities, such as stormwater management, wetland protection, wildlife monitoring, and construction impacts including light pollution and wildlife disruption, will be critical, especially for the protection of environmentally sensitive zones. The activities impacting these zones will be logged, and specific mitigation measures (e.g., wetland restoration, wildlife crossings) will be tracked in the risk register.
- **Emergency Response and Health and Safety Monitoring**: During construction, any health and safety incidents will be logged and evaluated. Emergency response protocols will be tested regularly, and any gaps in safety measures will be addressed promptly. Incident reports will be reviewed and updated in the project's risk register, and necessary changes to safety protocols will be communicated to the contractors and workers on site.

By integrating these proactive risk management and contingency measures, which include thorough environmental monitoring, the project will remain adaptable to challenges as they arise. This approach will help to minimise schedule delays and cost overruns, minimise, allowing for effective decision-making in real-time and reducing potential disruptions to the overall timeline or budget.

6.9 Maintenance and Lifecycle Planning

6.9.1 Overview

Proper maintenance and lifecycle planning are crucial components in ensuring the long-term functionality, safety, and cost-effectiveness of the EWA Extension. This planning not only optimizes the performance of roadway and associated infrastructure but also reduces the total cost of ownership over the project’s lifecycle. As the Proposed Project is expected to be a key transportation corridor, a well-designed maintenance strategy will help mitigate risks, enhance road safety, and maintain service continuity in the face of environmental and operational challenges.

6.9.2 Routine Maintenance

Routine maintenance activities aim to preserve infrastructure integrity and prevent premature deterioration. Key activities include:

- **Pavement**: Routine inspections, pothole repairs, crack sealing, and resurfacing to manage wear from traffic loads and weather.
- **Drainage**: Regular cleaning and maintenance of culverts, inlets, and stormwater pipes to allow for effective water flow, especially after heavy rain.
- **Vegetation Control**: Management of corridor vegetation to prevent overgrowth, protect sightlines, and maintain pavement integrity.

- **Signage and Lighting**: Inspections and repairs of signs, lighting, and signal systems for visibility and safety compliance.
- **Bridge and Structure Inspections**: Regular checks for structural integrity, particularly in flood-prone areas.

6.9.3 Long-Term Maintenance

Long-term maintenance activities include substantial interventions to extend the infrastructure's lifespan, using predictive models and inspections to schedule work. Major activities include:

- **Pavement Resurfacing**: Scheduled based on pavement design life, traffic, and condition.
- **Bridge Rehabilitation**: Major repairs, including deck replacements and structural reinforcements.
- **Utility Upgrades**: Coordination with utility providers for essential upgrades to underground and above-ground infrastructure.

6.9.4 Lifecycle Cost Analysis

The LCCA evaluates total ownership costs over the project's lifecycle, incorporating construction, routine and long-term maintenance, and potential unplanned costs. The analysis guides design and material choices to reduce long-term expenses while upholding PS. Key considerations include:

- **Pavement Durability**: Selection of durable materials to extend pavement lifespan.
- **Bridge Longevity**: Designing bridges with corrosion resistance and hydraulic capacity.
- **Utility Future-Proofing**: Installing adaptable infrastructure to avoid costly retrofits.
- **Climate Resiliency**: Integrating design features that withstand sea level rise and extreme weather.

6.9.5 Sustainability and Resiliency

To ensure the long-term durability of the EWA Extension, the project incorporates resiliency measures that address climate-related and environmental challenges, ensuring continued roadway functionality:

- **Stormwater Management for Flood Control**: Enhanced drainage systems manage heavy rainfall, preventing roadway flooding and protecting the corridor from erosion.
- **Erosion Control for Roadway Stability**: Measures such as reinforced slopes and vegetation management prevent soil erosion, stabilize the roadway, and reduce maintenance needs over time.
- **Use of Recycled Materials**: Recycled materials in pavement such as reclaimed asphalt pavement that is reprocessed from existing pavement removal, and recycled asphalt shingles contribute to infrastructure durability, lower maintenance costs, and extend the lifespan of the roadway. Recycled materials in embankments such as reclaimed concrete, foundry sand and steel slag can achieve similar goals.

These initiatives support long-term sustainability goals, minimising the environmental footprint and enhancing resiliency to environmental changes.

6.9.6 Digital and Smart Infrastructure Considerations

As the Proposed Project will be constructed in multiple phases and serve as a critical transportation corridor, accommodations for Digital and Smart Infrastructure components have been integrated into the conceptual design. The goal is to enable the roadway to support future advancements in transportation technologies, such as but not limited to vehicle-to-infrastructure and connected autonomous vehicle systems, while also enhancing sustainability, safety, and operational efficiency.

Key considerations include:

- **Integration of sensor systems**: Space has been allocated for potential sensor installations along the Proposed Project. These sensors could monitor traffic flow, environmental conditions, and roadway performance in real-time, allowing the system to adapt to changing conditions dynamically.
- **Fibre optic conduit**: The conceptual design includes provisions for installing fibre optic cables for high-speed data transmission. This infrastructure would facilitate communication between roadway systems, traffic management centres, and autonomous or connected vehicles. It also supports the integration of future smart technologies, ensuring the corridor remains relevant as digital infrastructure evolves.
- **Smart traffic management systems**: The design includes consideration for the installation of adaptive traffic signal controls at key intersections. These systems would allow real-time adjustments to signal timings based on traffic conditions, reducing congestion, and enhancing safety for vehicles, pedestrians, and micromobility users.
- **Real-time data collection**: Provisions have been made for devices that will collect data on road usage, weather conditions, and other factors that influence traffic flow and safety. This data can feed into integrated traffic management systems, helping improve roadway performance and safety in real-time.
- **Dynamic roadway lighting**: Smart lighting systems that adjust brightness based on traffic levels, time of day, or environmental conditions (e.g., fog, rain) are proposed. This improves safety while minimising energy use. These systems may also incorporate solar power or energy-efficient technologies, reducing operational costs and the environmental footprint of the project.
- **Emergency communication systems**: Dedicated channels for emergency communication will be considered, allowing law enforcement, medical services, and traffic control centres to manage emergencies more effectively. This system could include automatic detection of accidents or breakdowns, triggering immediate alerts to relevant authorities and adjusting traffic flows accordingly.
- **Traffic and incident detection systems**: In addition to smart traffic management, integrated systems will detect and respond to traffic incidents (e.g., accidents, stalled vehicles, traffic jams). These systems can automatically adjust traffic signals, trigger variable message signs, or reroute traffic in real time to reduce congestion and enhance safety.
- **Sustainability and energy efficiency measures**: Along with fibre optics, the project will explore opportunities for solar power integration along the corridor. Solar panels could power street lighting, traffic signals, or real-time data systems, contributing to sustainability goals and lowering operational energy costs.
- **Electric Vehicle (EV) infrastructure**: Future-proofing considerations include installing infrastructure for electric vehicle (EV) charging stations at strategic locations along the corridor. This would support the transition to electric mobility and align with sustainability initiatives, ensuring the project remains relevant in the context of evolving transportation technologies.

- **Resiliency to climate change**: Smart infrastructure systems will be designed with resiliency in mind, enabling real-time monitoring and response to extreme weather events, such as flooding or hurricanes. Systems may include flood sensors or integrated weather forecasting technologies that can adjust traffic flows or reroute traffic in response to hazardous conditions.

By integrating these digital and smart infrastructure elements into the conceptual design, the Proposed Project is positioned to evolve alongside technological advancements, maintain its long-term relevance and effectiveness, and contribute to the sustainability and resiliency of Grand Cayman's transportation network.

6.9.7 Coordination with Evolving Development and Infrastructure

To ensure that the Proposed Project EWA Extension remains adaptable throughout its lifecycle, coordination with future developments and evolving infrastructure is important. The study area is expected to experience changes in traffic patterns, intensification of land use and development, and the integration of advanced technologies. Key considerations for long-term coordination include:

- **Adaptability for Growth**: As traffic volumes increase and land use changes, future infrastructure upgrades may be required to ensure continued safe and efficient service. Planning must account for these shifts, ensuring that the roadway can handle higher capacity without major redesigns.
- **Integration of New Technologies**: The corridor should be prepared to accommodate advancements like autonomous vehicles, EV charging stations, and renewable energy systems. These elements will be critical for ensuring the project's relevance over the long term.
- **Future-Proofing for Upgrades**: The ability to upgrade infrastructure without significant disruption to service is critical. Features such as utility expansions or additional mobility technologies can be implemented with minimal downtime if provisions are made during the initial construction phase.

This approach ensures that the EWA corridor will remain effective and efficient, supporting Grand Cayman's transportation needs well into the future.

Proactive maintenance and lifecycle planning are key to preserving the functionality, safety, and efficiency of the Proposed Project. Through a combination of routine and long-term maintenance activities, coupled with sustainability and resiliency measures, the Proposed Project can be expected to serve the region for decades to come with minimal disruption. Continuous monitoring and periodic updates to the maintenance plan will allow the infrastructure to remain in optimal condition and that emerging technologies and development trends are integrated smoothly into the corridor's operation.

6.10 Environmental Considerations

The Proposed Project places a strong emphasis on minimising environmental impacts throughout design and construction. Proximity to sensitive ecological areas, such as the CMW and other protected habitats, guided strategic alignment and mitigation measures to preserve local ecosystems. The following approaches were applied to reduce the environmental footprint:

- **Alignment Adjustments**: The horizontal and vertical alignments were developed to avoid key environmental features and minimise encroachment on natural areas, such as the Mastic Reserve and NT owned properties.
- **Construction Best Practices**: To protect local hydrology and reduce sedimentation, the design includes hydraulic connectivity maintenance through bridges and culverts, along with erosion control measures to prevent sediment runoff into sensitive ecological areas.

These proactive strategies help protect sensitive habitats and establish a foundation for sustainable infrastructure during and immediately following construction.

6.10.1 Environmental Impact Mitigation

To support environmental preservation, different procedures, goals, and general practices have been identified to further environmental impact mitigation. At this stage of design, these ideas are identified as common practice and are related to the known parameters of the project. They represent goals that the NRA and detailed design team are striving for. As detailed design progresses, so should the level of detail in the mitigation measures. The measures should be tailored to the design of the proposed project to appropriately meet environmental mitigation needs.

Relating to drainage and hydrology features, it is recommended that construction in wetland areas be carried out "in the dry," using methods such as temporary diversion channels, pump-arounds, or temporary pipes to control existing water flow and allow construction to proceed safely without compromising the surface water run-off. Wetland areas temporarily impacted by culvert and pipe installation should be restored once construction is complete, including decompacting soil and re-establishing natural hydrology to maintain ecological balance.

For the construction of bridge abutments, piers, and other structural features, it is recommended that the detail designer prioritize maintaining hydraulic connectivity, and that erosion and sediment controls be installed before any earthwork begins at these sites. These practices will aide in the protection of the surrounding environment, particularly in sensitive areas such as the CMW.

Wherever possible, the use of temporary crossings of wetlands and other sensitive areas should be avoided or minimised. When such crossings are necessary, protective measures, including the use of geotextile fabric, equipment mats, or prefabricated pads, can be implemented to minimise impacts. Once construction is completed, any temporary wetland crossings can be restored to pre-construction contours. This phased access methodology is intended to reduce environmental impacts while facilitating efficient transport of materials and equipment to and from the site.

For the installation of highway lighting in environmentally sensitive areas such as the CMW and parrot habitats, careful consideration should be given to light pollution. Photometric analysis can be carried out to prevent light saturation in particular areas.

Further discussion of environmental impact mitigation as it relates to construction practices is discussed in **Section 6.8.5: Environmental Protection During Construction**.

To further support environmental preservation, the project integrates additional mitigation strategies targeting the area’s sensitive ecosystems. Key efforts include:

- **Disturbance Minimisation**: Alignment adjustments reduce impacts on the CMW and Meagre Bay Pond in comparison to the original corridor.

- **Hydraulic Connectivity for Ecosystem Health**: Bridges and culverts are designed to maintain natural water flow across ecological boundaries, reducing disruption to wetlands and supporting overall habitat health.
- **Erosion and Sediment Control**: Temporary and permanent measures focus on preventing sediment runoff into protected areas, maintaining ecological balance during and after construction.

6.10.2 Sustainability and Future-Proofing Measures

To support environmental sustainability and adaptability, the project includes measures that align with NRA's goals for resiliency, safety, and long-term efficiency:

- **Sustainable Infrastructure**: Solar panel canopies along the corridor generate renewable energy, offsetting approximately 703,556 tons of CO_2 over 30 years, contributing to the island's sustainability goals.
- **Green Energy Solutions**: Solar-powered transit shelters with LED lighting and real-time information support eco-friendly public transportation.
- **Water Management for Ecosystem Protection**: Drainage systems with hydraulic connectivity maintain local wetland health, protecting sensitive ecological areas from the effects of stormwater runoff.
- **Resilient Utility Infrastructure**: Future-proofed utility corridors accommodate growth and withstand rising sea levels, intense storms, and other climate impacts.
- **Digital and Smart Infrastructure**: Designed to reduce environmental impact, digital infrastructure enables efficient traffic flow, reducing emissions through smart traffic management.
- **Adaptability for Future Developments**: The corridor design allows for the addition of BRT lanes, new transit stops, and other emerging technologies, supporting sustainability with minimal disruption during future upgrades.

By integrating these sustainability and future-proofing measures, the project reduces immediate environmental impacts and establishes a robust, adaptable infrastructure to meet Grand Cayman's transportation needs well into the future.

6.11 Conclusion and Next Steps

The engineering design of the Proposed Project establishes a project that extends from the end of Section 1 of the EWA to the terminus intersection at Frank Sound Road.

Key components have been defined, including anticipated ROW (gazette) needs and associated costs, along with typical sections for the years 2026 to 2060, featuring travel lanes, transit lanes, a sidewalk, micromobility path, and utility corridors. The horizontal alignment, vertical profile, and intersection layouts have been established, and bridge structures have been suggested at critical points along the Proposed Project. Additionally, an initial material quantity and cost estimate has been developed.

With the foundation in place as part of this EIA, the Proposed Project is ready to proceed into the detailed design phase, which will involve further refinement and detailed development of the project.

6.11.1 Next Steps and Detailed Design Considerations

As the project advances to the next phase of detailed design outside of this EIA, it is recommended that the following elements be refined and completed:

1. **Detailed Surveying and Geotechnical Investigations**:
    - Additional surveying data is needed, especially in areas like the Will T Connector.
    - Geotechnical investigations are needed to assess the location and depth of peat deposits, ensuring appropriate treatment for roadway stability. Geotechnical investigations are also required for the Bridge structure foundations designs.
2. **Refinement of Bridge and Intersection Designs**:
    - Final designs for the bridge structures are needed with potential adjustments based on further analysis.
    - Intersection designs, particularly for roundabouts, will require detailed development to allow for functionality, including factors like truck movements, fastest path calculations, and sight distance assessments.
3. **Environmental Monitoring and Compliance**:
    - Environmental compliance measures, including obtaining necessary permits, are needed to be integrated into the design.
    - An environmental monitoring program is recommended to be implemented during construction to protect wetlands, wildlife habitats, and water quality.
4. **Drainage and Utility Coordination**:
    - Final drainage design is needed based on the final configuration of the profile and cross-slopes, with drainage inlets and outfall locations positioned according to drainage area analysis.
    - For any drainage option that advances to detailed design (Excellent Fit, Good Fit, or Acceptable Fit), further refinement of bridges, culvert sizing, placement, and outfall efficiency will be required to ensure adequate stormwater conveyance and post-storm drainage performance.
    - The alignment of utility corridors will need to be further refined to allow for long-term functionality and ease of maintenance.
5. **Hydraulic and Hydrologic Modelling:**
    - Hydrologic and hydraulic modelling is needed to be further developed and refined for baseline conditions during the detailed design using corrected LiDAR data and project-specific information including: topographical survey, geotechnical survey, and localized drainage systems.
    - Regardless of which drainage approach is ultimately selected for final design, further validation through detailed hydrologic analysis will be necessary to confirm stormwater capacity, drainage timeframes, and performance under varying storm conditions.
6. **Risk Management and Contingency Planning**:
    - A detailed risk management plan is recommended to address potential risks such as construction delays or geotechnical challenges.
    - Contingency plans will need to be created to manage cost overruns and schedule adjustments.
7. **Sustainability and Future-Proofing**:
    - Sustainable design practices need to be explored, including options for green infrastructure, solar-powered systems, and energy-efficient solutions.

    - Future-proofing the Proposed Project for long-term adaptability to future traffic demand and climate resiliency is recommended to be completed during detailed design.
8. **Roadway Modelling and Final Design Elements**:
    - Detailed modelling of intersections and bridge structures is needed so that cross-slope changes, superelevation, and lane/shoulder width tapers are properly accounted for.
    - The type, size and location of design elements such as median barriers, guardrails, and pavement markings need to be finalized.

As the design advances, completing these steps will help to allow the Proposed Project to meet the project's long-term goals of delivering safe, efficient, and environmentally sustainable infrastructure for Grand Cayman Island.

6.11.2 Community and Stakeholder Engagement

Community and stakeholder engagement has been an integral part of the EWA Extension project from the early stages. This engagement helped identify key community concerns and priorities, influencing the selection of the Proposed Project. Moving forward into the detailed design phase once the EIA is complete, ongoing design efforts will focus on refining the design details, addressing construction impacts, and ensuring that the community continues to be informed and involved throughout the process. Therefore, continued engagement will be necessary during the detailed design and construction phases to address specific design and construction concerns.

The recommended engagement process moving forward would include:

- **Detailed design consultations**: As the project moves into detailed design, focused stakeholder consultations will allow specific concerns about property impacts, traffic management, and environmental features to be identified and addressed. These consultations may include interactions with local residents, business owners, environmental groups, and relevant government agencies.
- **Public meetings before and during construction**: Public meetings may be held throughout the detailed design and construction process at key milestones to keep the community informed about project development, construction timelines, potential disruptions, and progress updates. These meetings would provide an opportunity for stakeholders to raise concerns about design features and construction impacts prior to project implementation.
- **Online updates and feedback channels**: The project-specific website and social media platforms would continue to be used to provide updates on the project. These platforms also serve as feedback channels, allowing community members to ask questions and provide input throughout the detailed design and construction phases.

6.11.2.1 Key Stakeholders

As the project moves into detailed design and construction, continued engagement with key stakeholders is recommended. These groups may include, but are not limited to:

- **Local residents and property owners**: As ROW acquisition progresses, affected property owners would be engaged in ongoing communication regarding property impacts, potential relocations, and compensation procedures.

- **Local businesses**: Engagement with businesses within the EWA study area can be employed to assist in minimising disruptions during construction.
- **Government agencies**: Collaboration with government agencies including the DoE, and Ministry of Planning, so that the project complies with regulatory requirements and aligns with broader planning objectives.
- **Environmental organizations**: Continued coordination with environmental groups is recommended for sharing information on implementing the environmental mitigation strategies identified during the EIA and on the construction practices being utilised to best protect sensitive ecosystems.
- **Utility providers**: Ongoing coordination with public and private utility providers would occur so that utilities are properly planned, relocated, or protected during construction, with minimal disruption to services.
- **Public transportation authorities**: As the project integrates transit lanes and other transit features, close collaboration with transit authorities will be needed to provide for efficient design and construction of transit infrastructure.

6.11.2.2 Engagement Objectives

The objectives of the engagement process during the detailed design and construction phases include:

- **Transparency**: Provide clear, timely communication about project developments, construction schedules, and potential impacts.
- **Mitigating construction impacts**: Proactively identify and best address concerns about construction-related disruptions, including noise, drainage, dust, traffic detours, and access restrictions.
- **Incorporating community feedback**: Continue to listen to community input, particularly regarding construction impacts and mitigation strategies, so that the project remains responsive to community needs.

6.11.2.3 Long-Term Community Benefits

While much of the engagement efforts during the detailed design and construction phases focus on design details, the long-term benefits of the Proposed Project will also be emphasized, including:

- **Enhanced mobility**: The project is expected to improve traffic flow and connectivity, offering benefits to drivers, public transit users, pedestrians, and cyclists.
- **Environmental stewardship**: Engagement with environmental stakeholders will assist in communicating the best practices that are being employed to preserve sensitive ecosystems and implement sustainability measures.
- **Economic growth**: By improving access to key areas of the island, the project is anticipated to help accommodate economic growth and provide opportunities for improved travel along the corridor.

6.11.3 Conclusion

As the Proposed Project for the Grand Cayman Island’s EWA Extension moves into the detailed design phase, it remains imperative to maintain community engagement and risk management while integrating sustainable and future-proofed infrastructure. These elements are crucial to delivering long-term transportation benefits, environmental protection, and economic growth.

6.11.3.1 Future Recommendations:

To address the inherent uncertainties and complexities of designing a major project over an extended timeline, the following measures are recommended for consideration:

- **Conduct Comprehensive Surveys and Analyses:** Implement detailed geotechnical, environmental, traffic, and economic impact analyses. These investigations are essential for confirming the underlying assumptions used in the project's planning stages and for addressing potential risks associated with physical and environmental factors.
- **Secure Necessary Agreements and Partnerships:** Establish comprehensive agreements with local governments, property owners, utility companies, and other key stakeholders. These agreements should cover aspects such as land use, access rights, utility relocations, and environmental mitigation measures. They are crucial for confirming the various aspects that underpin the project's assumptions and ensuring that there is alignment on the project's scope, design, and anticipated impacts.
- **Enhance Stakeholder and Community Engagement:** Conduct regular workshops and maintain ongoing communication to ensure that project development aligns with community needs and expectations while fostering local support and cooperation.
- **Adopt Advanced Technologies and Resiliency Planning:** Integrate smart technologies and develop resiliency strategies to adapt to changing environmental conditions and future technological advancements.
- **Ensure Safety:** Incorporate robust public safety measures to ensure the safety and security of the corridor users.
- **Facilitate High-Level Integration:** Develop a high degree of integration in the planning and execution phases through collaborative approaches such as Integrated Project Delivery. This should involve close cooperation among all project participants from the onset to enhance efficiency and innovation, ensuring that complex project components are harmoniously designed and implemented.

By proactively addressing these key areas, including thorough agreement frameworks and advanced integration strategies, the EWA Extension will not only meet current transport demands but also adapt to future developments, ensuring its relevance and utility for generations to come.

7 Transportation and Mobility

As stated in the ToR, transportation investments like the Proposed Project can significantly affect how individuals live and travel, impacting transportation measures such as travel time, employment access, roadway resiliency, and multimodal access. This chapter assesses the Proposed Project's potential impact on these components, with the goal of implementing a new roadway facility that effectively meets Grand Cayman's transportation needs while minimising impacts to the natural, cultural, and human environments.

This Transportation and Mobility chapter of the ES covers the following:

- Describes the methodology for transportation and mobility analyses;
- Establishes baseline transportation and mobility conditions within the study area, including traffic performance;
- Identifies the potential benefits and adverse impacts due to the project;
- Assesses the significance of these potential impacts;
- Offers mitigation for the project's potential negative transportation and mobility impacts.

This chapter considers the Proposed Project's anticipated impacts on transportation and mobility components such as travel demand, resiliency, travel times, intersection delay, safety, and multimodal access. Baseline Conditions, which equate to 2021 Existing Conditions, were established using a variety of traffic-related data sources. Within this Transportation and Mobility chapter, the Future No-Build conditions include planned land developments and roadway infrastructure projects that the NRA previously provided, excluding the EWA Sections 2 and 3 as well as the Will T Connector.

7.1 Constraints and Limitations

This Transportation and Mobility chapter is primarily based on traffic evaluations using modelling software PTV VISUM 2022 (Service Pack 1-2) and PTV VISTRO 2022 (Service Pack 0-11), which rely heavily on the availability of data such as traffic counts, travel times, roadway conditions, land use, and demographic information. Incomplete or outdated data sources can create limitations in the analysis results. This evaluation lacked key data sources including official demographic forecasts, detailed development plans and economic models, approved transit plans, on-board transit surveys, travel behaviour surveys, bike/pedestrian counts and surveys, business establishment surveys, road closure data, travel times during road closures, and travel times outside of the project study area. This evaluation also lacked comprehensive crash data to assess potential safety impacts of the Proposed Project.

Additionally, the Future No-Build and Proposed Project analyses are largely dependent on the NRA's assumptions about future demographics, land use, and roadway changes, which inherently assume some level of uncertainty. The NRA, stakeholders, and various agencies in Grand Cayman also collaborated to develop land use assumptions for three future growth scenarios to address a range of potential development patterns (see **Section 7.2.2.2: Stakeholder Consultation**). The collaborative interdisciplinary approach used to identify these future growth scenarios also involves a degree of uncertainty.

7.2 Assessment Methodology

This section describes the methodology used to assess transportation and mobility elements as part of the EIA process. This methodology comes from the ToR and follows established Cayman Islands laws and international standards and practices, which are described in the following sections.

7.2.1 Applicable Standards and Guidelines

Relevant international standards/guidelines and Cayman Island government reports were reviewed to determine the methodology used to assess transportation and mobility. The assessed standards and reports included the following.

7.2.1.1 Cayman Reports

Reports from Cayman Islands government agencies include:

- *Cayman Islands' Census of Population and Housing 2021* – ESO

7.2.1.2 UK, US, and International Standards

UK Department of Transport's WebTAG standards include:

- *WebTAG Unit M1.1 Principles of Modelling and Forecasting*
- *WebTAG Unit M4 Forecasting and Uncertainty*
- *WebTAG Unit M3.1 Highway Assignment Modelling*

Additional UK standards include:

- *The Green Book*, 2022 – UK HM Treasury

US standards include:

- *Highway Capacity Manual, Sixth Edition: A Guide for Multimodal Mobility Analysis*, 2022 – Transportation Research Board
- *Highway Safety Manual*, 2014 – American Association of State Highway and Transportation Officials
- *A Policy on Geometric Design of Highways and Streets*, 2018 – American Association of State Highway and Transportation Officials
- *Crash Modification Factors*, 2023 – Federal Highway Administration

Additional US references include:

- *Visualizing and Measuring Low Stress Bicycle Network Connectivity in Delaware*, 2016

7.2.2 Data Sources Evaluated

7.2.2.1 Land Use

The Cayman Islands Economics and Statistics Office (ESO) 2021 Census of Population and Housing was referenced to determine historical district growth and to forecast the population growth anticipated for future years. Demographic and land use inputs such as households, population, hotel rooms, education, etc. were first developed for 2021, incorporating completed developments identified by the NRA. These inputs relied on a combination of census data from the ESO, completed development data provided by the NRA, and school enrolment data from the Department of Education Services. For future analysis years 2026, 2036, and 2046, the model inputs are based on planned development projects identified by the NRA over the next 30 years, including commercial and residential developments and Planned Area Developments.

7.2.2.2 Stakeholder Consultation

The EWA EIA Steering Committee chose to use a 50-year time horizon, 2074, that would represent the life-cycle year for the Proposed Project and the common year used for all evaluations. For future year 2074, three land use scenarios of low, medium, and high population growth were developed based on input from stakeholders and various agencies in Grand Cayman, as detailed in **Appendix C - Land Use Planning Charrette Summary Memorandum**.

7.2.2.3 Field Data

To support the transportation analysis, the NRA provided field data including:

- Turning Movement Counts (TMCs) – Traffic counts collected during the peak hours at key study intersections to support analyses for existing and future intersection delay in the study area.
- Automatic Traffic Recorder (ATR) Counts – Continuous traffic counts collected over multiple days, including both peak and off-peak traffic volumes to determine peak hours and peak periods.
- Travel Time Runs – End-to-end corridor runs in both directions of key roadway segments during both peak and off-peak hours to ensure analyses are calibrated to existing conditions within the study area.

For additional information on these data sources, see **Appendix E - Shortlist [Alternatives] Evaluation: Attachment A – Traffic [Transportation & Mobility] – Assessment of Alternatives**.

7.2.2.4 Travel Demand Model

A typical travel demand model (TDM) is used to forecast future traffic flows in a transportation system based on demographic and land use data, available travel modes, the transportation network (number of lanes, intersection traffic control, vehicular speed), and travel costs. These models are generally used to evaluate the impact of transportation improvements or changes in land use by forecasting the future traffic conditions.

The GCM is a four-step trip-based TDM model developed by the NRA using PTV VISUM modelling software to encompass the diverse spectrum of travel patterns observed on Grand Cayman, including that of residents of the island, short-term visitors such as cruise passengers, and long-term visitors who usually arrive via the airport. The GCM underwent a calibration process where model parameters were adjusted to ensure the model accurately reflects observed travel patterns, drawing upon a comprehensive dataset including census socio-economic data, cruise passenger surveys, long-term visitor surveys, and traffic counts collected across the island. The original baseline model calibration—including model structure, assumptions, and validation results—was documented and reviewed by outside experts as part of an independent review.

For the EWA EIA, the model was updated to incorporate more recent data, with particular focus on the roadways of the districts of Bodden Town, North Side, and East End. Using the 2021 ESO census data, GCM land use inputs and demographic data were updated to represent Baseline Conditions (**Appendix E - Shortlist [Alternatives] Evaluation: Attachment A – Traffic [Transportation & Mobility] – Assessment of Alternatives**). Within the study area, the GCM was calibrated to existing count data and travel time data to ensure the model reflects observed existing conditions and can ultimately forecast realistic results under future year conditions (**Appendix E - Shortlist [Alternatives] Evaluation: Attachment A – Traffic [Transportation & Mobility] – Assessment of Alternatives**).

The GCM was used as the primary tool to evaluate the impacts of the Proposed Project on future traffic conditions. These results are discussed in subsequent sections of this chapter.

7.2.2.5 Traffic Analysis Model

Once traffic volumes were forecasted for the analysis years using VISUM, they were analysed using PTV VISTRO 2022 (VISTRO). VISTRO is a macroscopic capacity analysis computer program that follows methodologies from the Highway Capacity Manual (HCM), which is a guidebook documenting performance measures, analysis techniques, and concepts to aid in assessing intersection delay. Using VISTRO, existing roadway geometries were coded, including study intersection configurations, speed limits, lane widths, roadway grades and overall intersection peak hour factors (PHFs), which are used to analyse the busiest 15 minutes of the peak hour when the intersection is most stressed. Therefore, intersection delay could be discerned at the intersection, approach, and individual traffic movement levels to best determine where additional improvements may be needed. Intersection delays were analysed for the 6:00 to 7:00 AM and 5:00 to 6:00 PM peak hours for all years of both Future No-Build and Proposed Project conditions (**Section 7.4.6: Intersection Delay** and **Appendix G.1: VISTRO Reports**).

7.3 Baseline Conditions

Baseline Conditions reflect 2021 Existing Conditions to provide context for understanding current transportation needs. This section discusses these Baseline Conditions as they relate to the transportation and mobility evaluation, as well as the underlying assumptions applied to the future year analyses of the Proposed Project.

7.3.1 Study Area

The transportation and mobility study area spans from Hirst Road to Frank Sound Road, encompassing the existing coastal roads of Shamrock Road and Bodden Town Road, as well as the entire proposed EWA corridor. Baseline Conditions of the study area are shown in **Figure 7-1**.

Figure 7-1: Transportation and Mobility Study Area, Baseline Conditions

Grand Cayman comprises five districts as shown in **Figure 7-2**. Given the location of the project, the transportation analysis primarily discusses impacts on the districts of Bodden Town, North Side, and East End. Speed limits in Grand Cayman range from 25 to 50 mph as shown in **Figure 7-3**.

Figure 7-2: Grand Cayman Districts

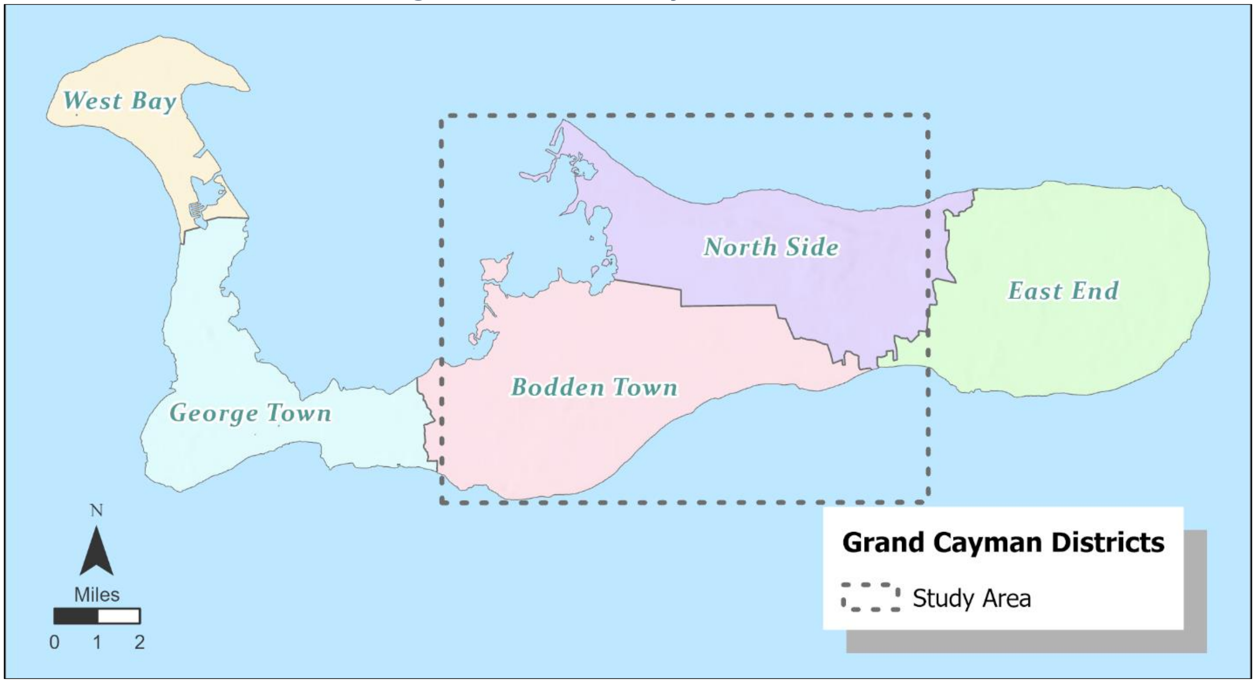
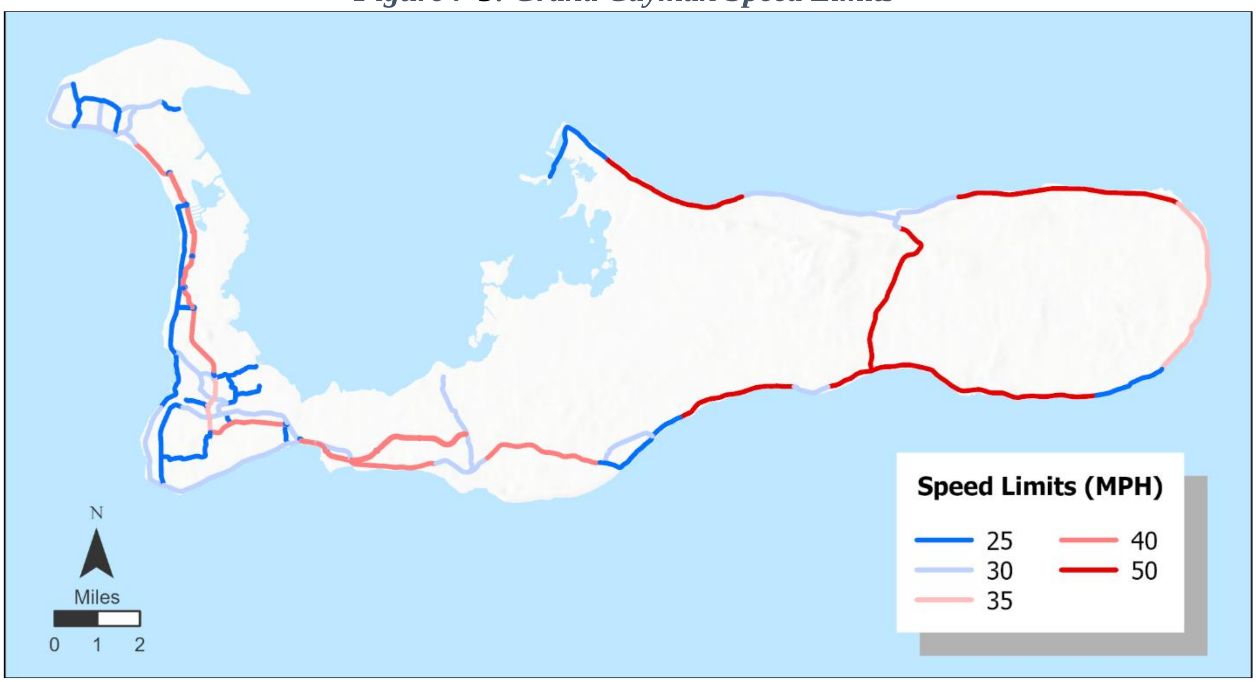


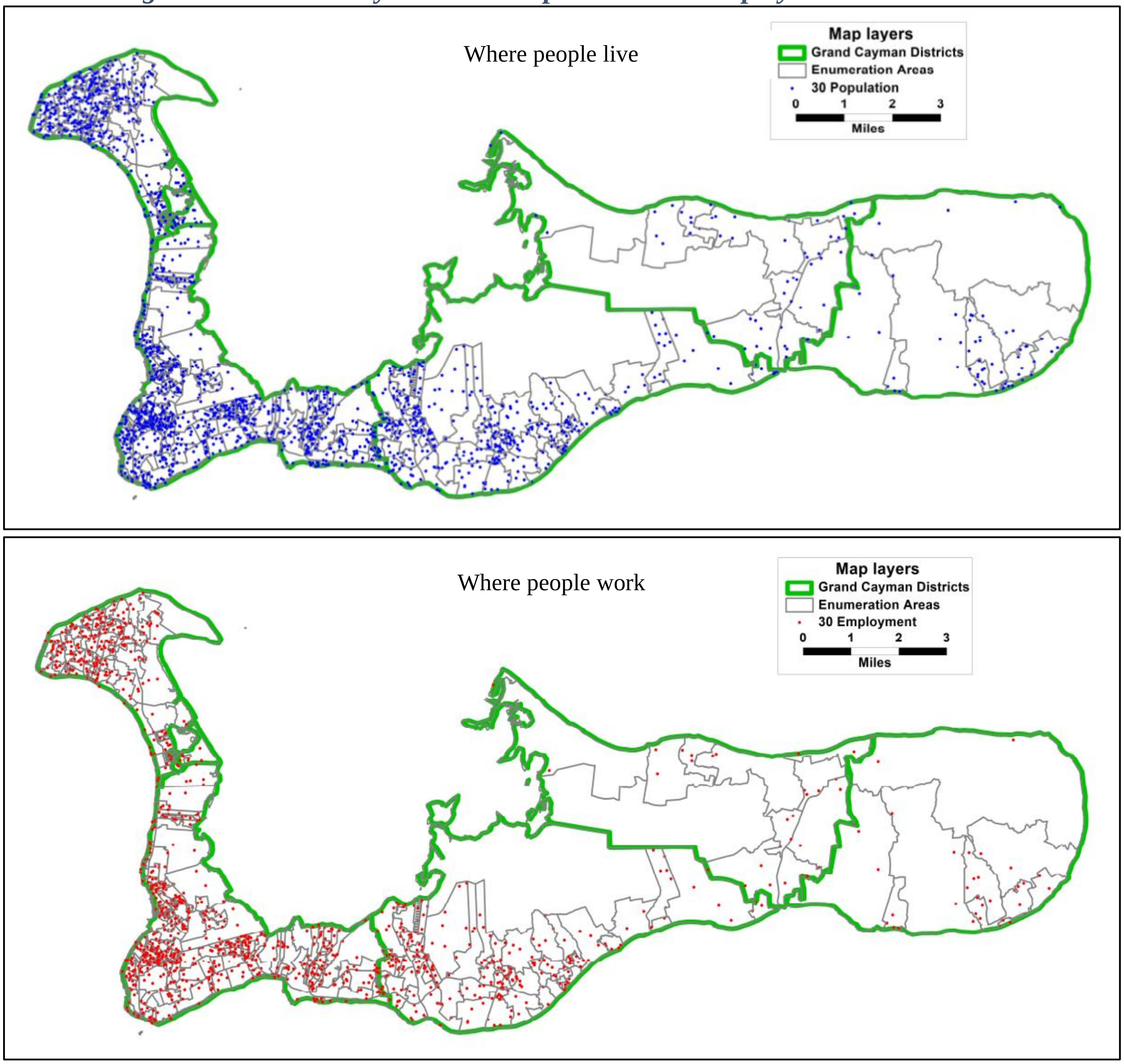
Figure 7-3: Grand Cayman Speed Limits



7.3.2 Population and Employment Centres

Figure 7-4 illustrates the distribution of Grand Cayman's population and employment centres based on 2021 ESO census data, showing a large majority of population and jobs are in George Town and West Bay. Residents of North Side and East End face long-distance commutes to access the employment opportunities in George Town and West Bay, making these jobs less accessible for them.

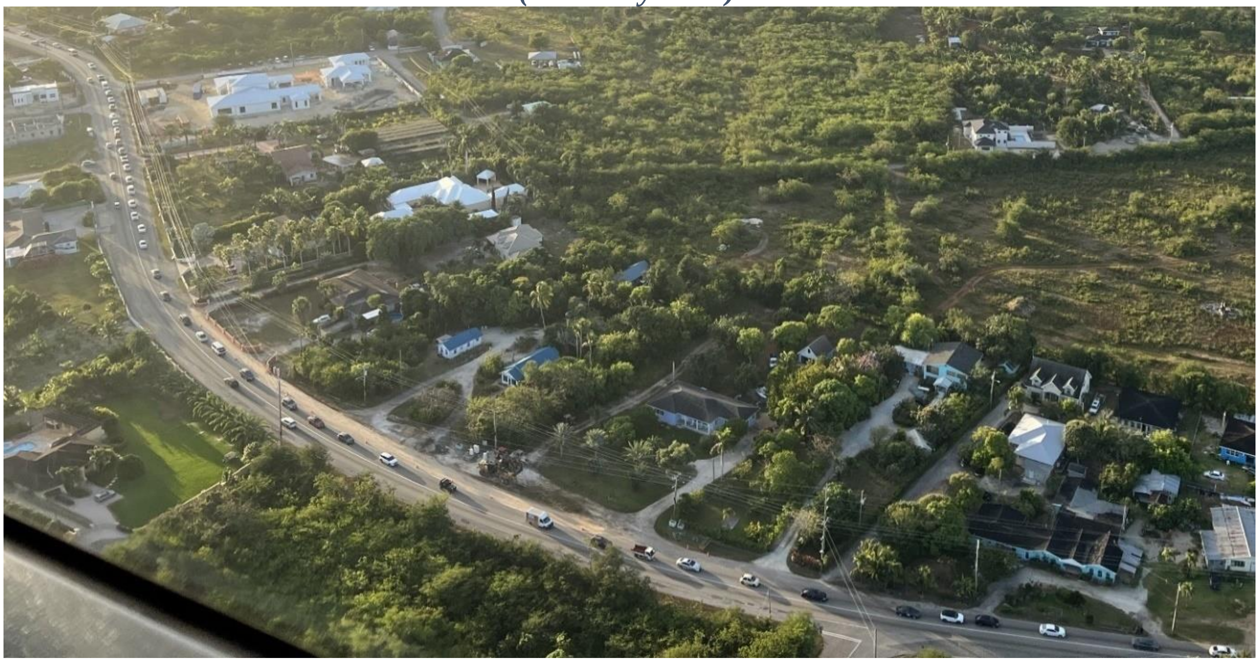
Figure 7-4: Grand Cayman 2021 Population and Employment Distribution



7.3.3 Traffic Conditions

Residents of North Side and East End face widespread congestion on the existing coastal roads of Shamrock Road and Bodden Town. **Figure 7-5** shows existing morning peak hour congestion along westbound Shamrock Road near Will T Road that was observed in February 2023, illustrating the congestion issues prevalent in the study area. These conditions are projected to worsen as Grand Cayman's population continues to grow, highlighting the need for additional roadway infrastructure.

Figure 7-5: AM Westbound Congestion, Shamrock Road Looking East Near Will T Road (February 2023)



Drivers utilise Shamrock Road, Bodden Town Road, and Frank Sound Road to access the eastern districts of Bodden Town, North Side, and East End. These facilities are all two-lane, undivided roadways, with speed limits as high as 50 mph. High-speed travel with vehicles traveling in opposite directions just feet apart is less than ideal from a safety perspective, and is further compounded by the number of cross-streets and driveways found throughout the roadway network. As Grand Cayman's population continues to grow, the safety conditions along these roads are expected to worsen.

As described in **Section 7.2.2.5: Traffic Analysis Model**, PTV VISTRO was used to analyse Baseline Conditions in terms of intersection delay, which is the amount of time each vehicle is slowed down when driving through an intersection. Based on existing traffic volumes and roadway conditions, **Section 7.4.6: Intersection Delay** summarizes existing intersection delay at key locations in the study area for 2021 Baseline Conditions**.**

Under Baseline Conditions, Shamrock Road and Bodden Town Road often experience vehicular traffic congestion and lack consistent provision of sidewalks to protect pedestrians. **Figure 7-6**, taken in July 2023 during midday travel conditions, illustrates this lack of sidewalk and/or bicycle facilities as well as inconsistent shoulder provisions on either side of Bodden Town Road, near Frank Sound Road. Pedestrians and bicyclists are forced to share the road with cars, creating multiple conflict points for all users and demonstrating a need for separated pedestrian and bicycle facilities.

Figure 7-6: Bodden Town Road Near Frank Sound Road Looking West (July 2023 – Midday)

7.3.4 Peak Hour Selection

As discussed in **Section 7.2.2.3: Field Data**, the NRA collected TMC and ATR traffic count data in 2023 along roads within the study area. This data reveals a directional pattern of travel during the AM and PM periods, with commuters from Bodden Town, North Side, and East End predominantly traveling westbound in the AM and eastbound in the PM. The 2023 ATR data indicates that the majority of westbound AM traffic occurs between 6:00 and 7:00 AM, while most eastbound PM traffic occurs between 5:00 and 6:00 PM. Therefore, the 6:00 to 7:00 AM and 5:00 to 6:00 PM hours were selected as the "peak" hours for modelling purposes to evaluate the impacts of the Proposed Project. For additional information on the data sources used to select the peak hours, see **Appendix E - Shortlist [Alternatives] Evaluation: Attachment A – Traffic [Transportation & Mobility] – Assessment of Alternatives**.

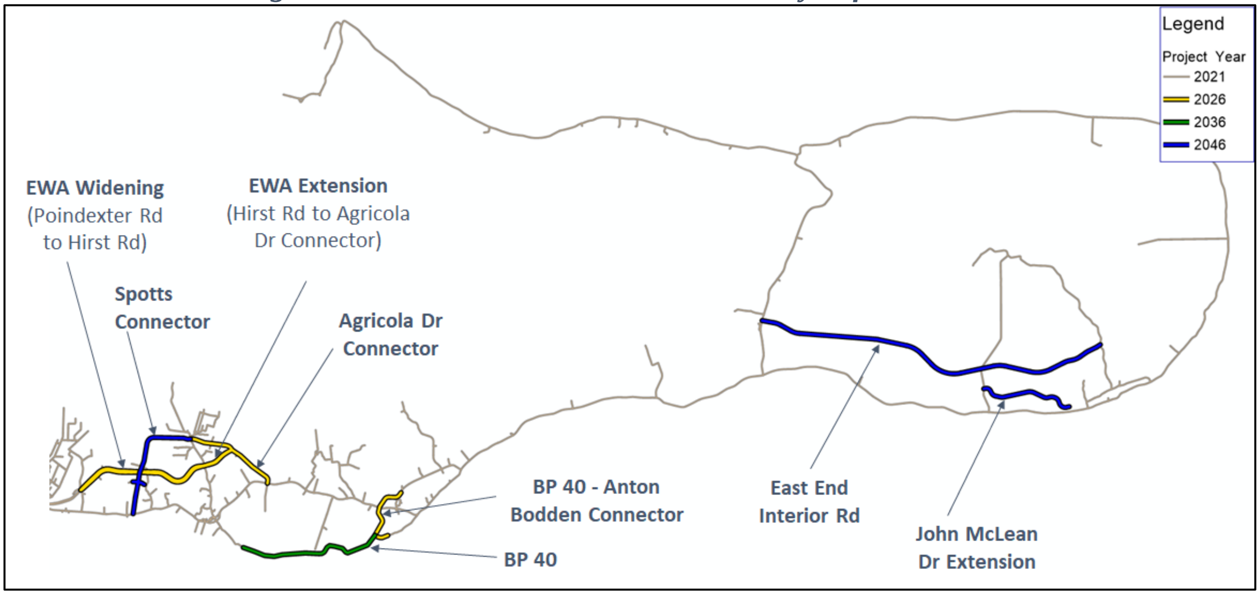
7.3.5 Future Year Assumptions

Planned Future Roadway Infrastructure

The NRA provided information regarding planned future roadway projects to reflect the roadway network of each future horizon year. The Future No-Build and Proposed Project include the planned improvements anticipated to be in place for the respective year. This evaluation incorporates these planned projects to capture the context of the entire project life cycle by representing the plan for future roadway infrastructure; however, inclusion of these projects does not imply that they are approved or funded for implementation.

Figure 7-7 displays the location of planned future roadway infrastructure assumed within the EWA EIA traffic study area for future years 2026, 2036, and 2046, which were incorporated into both the Future No-Build and Proposed Project discussed in this chapter. The 2074 No-Build and Proposed Project include all 2026, 2036, and 2046 planned improvements; the NRA did not provide any additional planned roadway infrastructure projects from 2046 to 2074.

Figure 7-7: NRA Planned Future Roadway Infrastructure



The 2026 planned roadway infrastructure includes the following projects, which are assumed in both the Future No-Build and the Proposed Project conditions:

- **EWA Extension** to Woodland Drive
- **Agricola Drive Connector** from EWA to Agricola Drive – one lane in each direction
- **EWA Widening** between Tomlinson Roundabout and Hirst Road – two lanes in each direction
- **EWA Widening** between Silver Oaks Roundabout and Tomlinson Roundabout – three lanes in each direction
- **Parallel Service Road** from Silver Oaks Roundabout to Red Bay via Grand Harbour development
- **Bobby Thompson Way (BTW) & LPH Widening** – three lanes in each direction
- **LPH Extension** to Outpost Road – one lane in each direction
- **Agnes Way Extension** from LPH to Cayman Enterprise and Fairbanks Road – one lane in each direction
- **Fairbank Road Widening** between LPH and Agnes Way Ext. – two lanes in each direction
- **Airport Collector Road (ACR)** to Industrial Park – one lane in each direction
- **Eastern Avenue Extension** from Elgin Avenue to Smith Road – one lane in each direction
- **Godfrey Nixon Way (GNW) Extension** to North Church Street – one lane in each

direction

- **Olympic Way Connector** to Academy Way for school/stadium complex – one lane in each direction
- **Printer Way** widened to two-direction road from Elgin Avenue to Shedden Road – one lane in each direction
- **ETH Widening** between North Sound Road and ACR– three lanes in each direction
- **ETH Connector** to Reverend Blackman Road – one lane in each direction
- **Canal Point Drive Connector** to West Bay Road – one lane in each direction
- **BP40 – Anton Bodden Connector** to Manse Road, including roundabout at Shamrock Road – one lane in each direction

Both the 2036 No-Build and Proposed Project conditions include all 2026 planned improvements as well as the following additional projects:

- **ACR –** Full build out between ETH and Airport – two lanes in each direction
- **Roberts Drive Extension** between North Sound Road and Dorcy Drive – one lane in each direction
- **Eastern Avenue Extension** from Shedden Road to Elgin Avenue and from Smith Road to Outpost Street – one lane in each direction
- **South Sound By-Pass Corridor –** one lane in each direction
- **LPH Extension** to Walkers Rd – two lanes in each direction between Bobby Thompson Way and Outpost Street; one lane in each direction between Outpost Street and Walkers Road
- **Fairbanks Road Widening** between Cayman Enterprise and LPH – two lanes in each direction
- **Hell Road Extension** to Northwest Point Road – one lane in each direction
- **BP 40 coastal** collector roadway from Pedro Castle Road to BP 40 Anton Bodden Connector – one lane in each direction
- **Godfrey Nixon Way Connectors** to Fort Street and Bodden Road – one lane in each direction

Both the 2046 No-Build and Proposed Project conditions include all 2026 and 2036 planned improvements as well as the following additional projects:

- **ACR to West Bay Road connectors** with two branches as collector roadways (one connector to Jasmin Blossom Way and another to Marbel Drive)
- **South Sound By-Pass Corridor Widening –** two lanes in each direction along the main section to Cayman Enterprise City from Old Crewe Road
- **Agnes Way Connector widening** – two lanes in each direction
- **South Sound Road -** two lanes in each direction from Shamrock Rd/Crewe Rd to Old Crewe Road
- **Spotts-Connector** - New connector from International College Cayman Islands and Hirst Road to the EWA at Chime Street, then to Shamrock Road – one lane road in each direction

- **Extension of John McLean Drive to High Rock Drive** – one lane in each direction
- **East End Interior** – between southern Spur of the EWA corridor by Clifton Hunter High School to Farm Road – one lane in each direction

The 2074 No-Build scenario includes all 2026, 2036, and 2046 planned improvements. No additional planned roadway infrastructure projects were provided from 2046 to 2074. For additional figures illustrating the remaining planned projects outside the EWA EIA study area from 2026 to 2046, refer to **Appendix E - Shortlist [Alternatives] Evaluation: Attachment A – Traffic [Transportation & Mobility] – Assessment of Alternatives**.

7.3.5.1 2074 Land Use Scenarios

As discussed in **Section 7.2.2.2: Stakeholder Consultation**, three land use scenarios of low, medium, and high population growth were developed for future analysis year 2074 based on input from stakeholders and various agencies in Grand Cayman. The Shortlist Alternatives Evaluation carried forward the 2074 Medium Growth scenario as the "core scenario" of these three land use scenarios to reflect the most realistic set of assumptions based on WebTAG Unit M4. However, this Transportation and Mobility chapter extends beyond the Shortlist Alternatives Evaluation by evaluating all three growth scenarios to account for the uncertainty in future development patterns and ascertain the Proposed Project's ability to accommodate these variations in development assumptions. A summary of projected population by district is provided in **Table 7-1**. The forecasted growth assumptions for future years 2026, 2036, and 2046 were also developed to coincide with the 2074 Medium Growth ("core") scenario.

Table 7-1: 2074 Scenario Population Totals

District	2074 Low Growth	2074 Medium Growth	2074 High Growth
George Town	49,807	67,919	98,173
West Bay	26,124	29,312	59,764
Bodden Town	23,152	22,532	61,865
North Side	4,204	6,269	29,870
East End	11,713	8,968	50,328
Grand Cayman	115,000	135,000	300,000

This evaluation assumed the same planned future roadway infrastructure assumptions for each of the three 2074 land use scenarios. **Figure 7-8** through **Figure 7-11** illustrate the planning charrette maps and corresponding map legend used to develop the land use assumptions for all three 2074 growth scenarios. Key differences between the scenarios include both the magnitude of growth as well as the spatial distribution of development across the island.

Figure 7-8: Land Use Map Legend

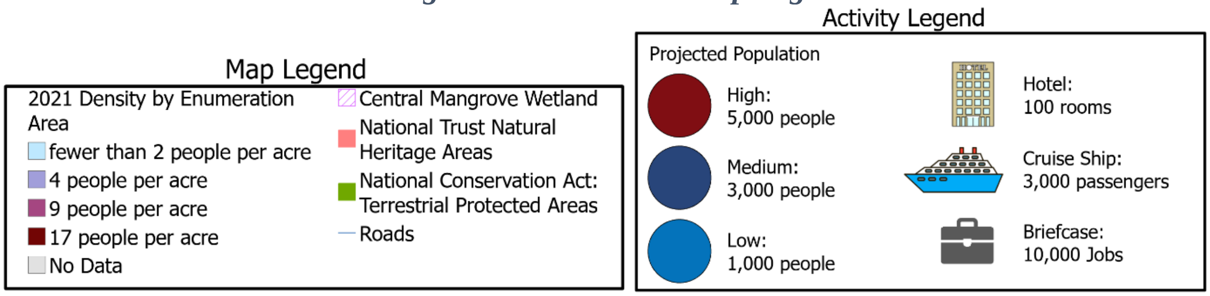


Figure 7-9: 2074 Low Growth Land Use Charrette Map

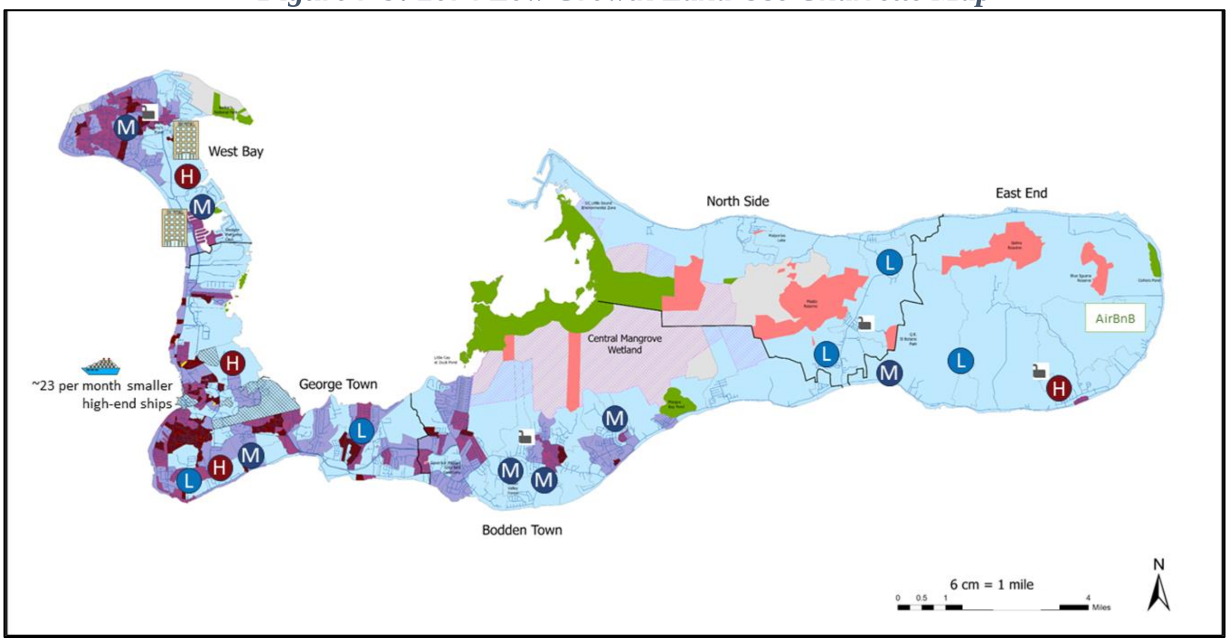


Figure 7-10: 2074 Medium Growth Land Use Charette Map

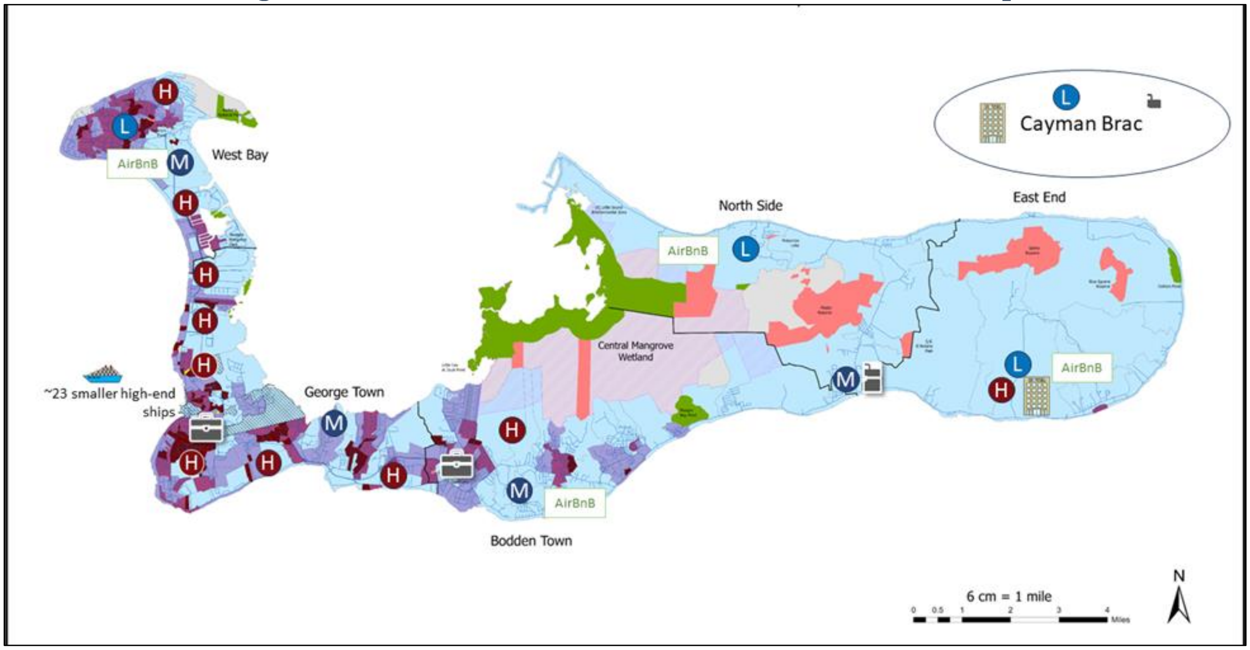
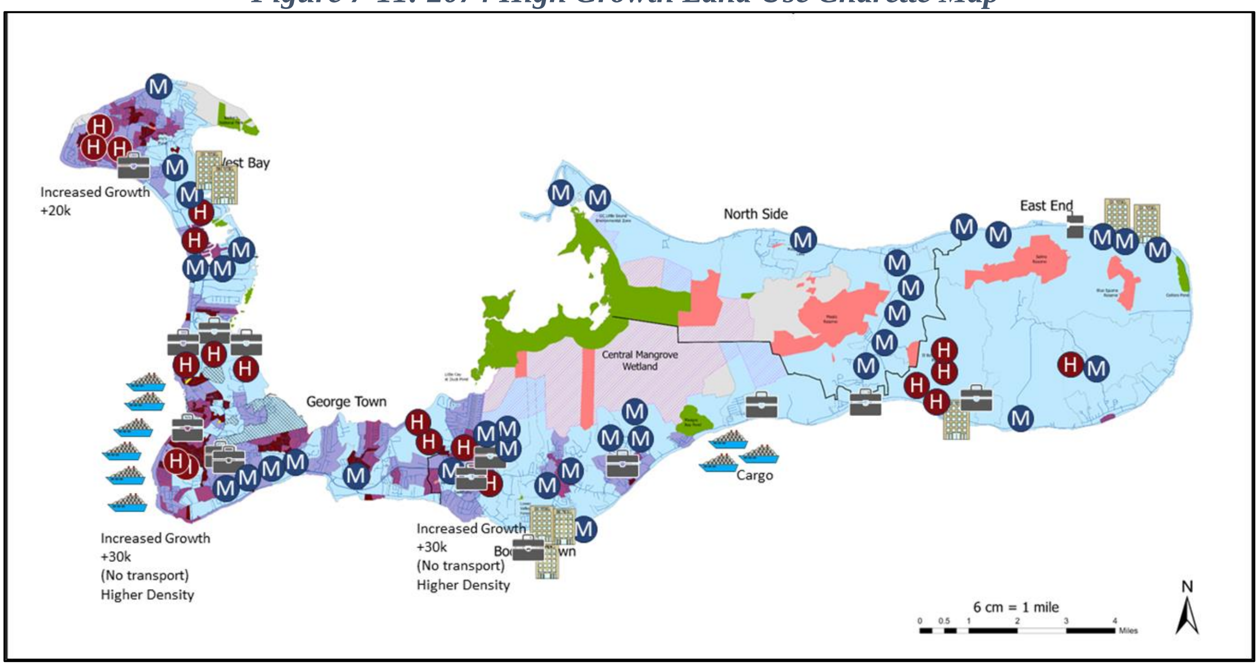


Figure 7-11: 2074 High Growth Land Use Charette Map



2074 Population Growth Assumptions

By 2074, the Low Growth scenario assumes a total population of 115,000 people, with most population growth in West Bay and George Town. This scenario also assumes some medium-density growth in East End and along the coastal road in east Bodden Town, as well as some low-density growth in North Side.

In contrast, the Medium Growth scenario assumes a total population of 135,000 people, with most growth concentrated in West Bay and George Town along with comparatively low-density growth in Bodden Town, North Side, and East End. Although the Medium Growth scenario slightly raises the island-wide population compared to the Low Growth scenario, it also indicates lower populations in the eastern districts of Bodden Town and East End, likely leading to fewer trips from those areas.

The High Growth scenario assumes a total population of 300,000 people by 2074, with significant growth throughout the island, including in eastern districts Bodden Town, North Side, and East End. The High Growth scenario more than doubles the populations of both the Low and Medium Growth scenarios, likely causing extreme congestion on the roadway network.

2074 Employment Growth Assumptions

The three scenarios vary widely regarding both the magnitude and spatial distribution of employment growth. The Low Growth scenario assumes modest employment growth spread relatively evenly across all districts.

The Medium Growth scenario envisions larger employment centres in George Town, Bodden Town, and on the border between North Side and East End. This development pattern is expected to allow residents of Bodden Town, North Side, and East End to take shorter commutes to local job opportunities, rather than traveling longer distances to George Town or West Bay.

The High Growth scenario assumes that most employment will be concentrated in George Town and Bodden Town, with additional employment centres also developed throughout West Bay, North Side, and East End.

2074 Cargo and Tourist Assumptions

The Low Growth and Medium Growth scenarios maintain both the existing cargo port and the existing cruise port locations, but they assume there will be smaller cruise ships arriving less frequently. In contrast, the High Growth scenario assumes the cargo port facility will relocate to Bodden Town. The High Growth scenario also maintains the existing cruise port location in George Town but assumes the number of cruise ships and passengers will grow.

In the Low Growth scenario, hotel development is mainly concentrated in West Bay and along Seven Mile Beach. In contrast, the Medium Growth scenario primarily assumes hotel growth in East End, with higher Airbnb growth spread relatively evenly across all districts. The High Growth scenario assumes hotel growth predominantly occurs in West Bay, Bodden Town, and East End.

7.4 Project Impacts

This section describes the potential impacts to Transportation and Mobility that are estimated to occur as a result of the Proposed Project. The Future No-Build condition is also included as a basis for comparison to demonstrate the impacts and benefits of the Proposed Project. The Proposed Project is described in **Chapter 6: Proposed Project - Engineering Features**. Potential construction impacts along with potential operations impacts are included in this section. The Proposed Project is anticipated to be constructed in phases with the initial phase focusing on two travel lanes (i.e., one travel lane in each direction) and utility preparation, while future phases will gradually expand to include additional vehicular travel lanes, transit lanes, and other infrastructure elements. The number and type of estimated intersection access points is also included as part of the phasing as described in **Section 6.6.9: Intersections**.

Due to the phasing of the construction timeline, the future years 2026, 2036, 2046 and three growth scenarios for 2074 (projected low, medium and high population/development growth) were analysed for this discipline. Assumptions were made regarding the potential implementation year of each of the discrete project phases. After the initial phase of the project, assumed to occur in 2026, construction of subsequent phases will occur based on a combination of demand for the additional transportation supply and available funding for construction. The 2036, 2046, and 2060 years used for the EIA are based on an anticipated pace of demand and availability of funding. If the population on the island continues to grow and create demand for additional capacity, the second phase of the project may begin earlier if funding is available. Conversely, if population grows more slowly than projected, the second phase of the project may be constructed later than anticipated. If transit demand grows, the transit lanes may be implemented earlier. If not, they may be implemented at later phases.

The phasing of the construction has been carefully designed to minimise environmental impact and optimise the placement of features within the corridor. The construction timeline prioritises reducing impact to the northern part of the corridor for as long as possible, preserving the natural state of the environment and postponing any associated development that could occur as a result of the corridor's construction. Consequently, the initial build year of 2026 will focus on constructing the southern part of the corridor, with subsequent phases gradually moving northward. The Proposed Project's phasing and constructability considerations are described in further detail in **Section 6.8: Phasing and Constructability.**

In this Transportation and Mobility chapter, the Future No-Build is used as a basis for comparison to demonstrate the impacts and benefits of the Proposed Project. For each future analysis year, No-Build conditions are defined as follows:

- No-Build conditions for 2026 include the 2026 land use assumptions with the 2026 planned future roadway infrastructure.
- No-Build conditions for 2036 include the 2036 land use assumptions with the 2036 planned future roadway infrastructure.
- No-Build conditions for 2046 include the 2046 land use assumptions with the 2046 planned future roadway infrastructure.
- No-Build conditions under the 2074 Low Growth scenario include the 2074 Low Growth land use assumptions with the 2046 planned future roadway infrastructure.
- No-Build conditions under the 2074 Medium Growth scenario include the 2074 Medium Growth land use assumptions with the 2046 planned future roadway infrastructure.
- No-Build conditions under the 2074 High Growth scenario include the 2074 High Growth land use assumptions with the 2046 planned future roadway infrastructure.

7.4.1 Proposed Project Assumptions

The EWA Extension is proposed to run parallel to the existing coastal road, extending from Woodland Drive/Agricola Drive Connector to Lookout Road and Frank Sound Road. The Proposed Project consists of the following:

- EWA Section 2 from Woodland Drive/Agricola Drive Connector to Lookout Road
- EWA Section 3 from Lookout Road to Frank Sound Road
- Will T Connector, which consists of three access points along EWA Section 2, providing access to existing neighbourhoods located along the coastal road

The Proposed Project is assumed to originally be built in 2026 as a divided roadway with a single lane in each direction and a median barrier as shown in **Figure 7-12**, with a design speed of 50 mph (80 KPH). The Will T Connector is assumed to be constructed by 2026 with one lane in each direction. Along the EWA, additional travel lanes will be constructed during interim years by section as needed based on additional demand. Future phases of the project will also include corridor lighting, dedicated transit lanes, sidewalks, micromobility paths, and a solar canopy (**Figure 7-13** and **Figure 7-14**). While construction for all components is expected to be completed by 2060, the Transportation and Mobility chapter evaluates these elements using 2074 land use assumptions. The assumed component sequencing for the Proposed Project is provided for Section 2 (**Table 7-2**) and Section 3 (**Table 7-3**). Additional roadway design information including detailed cross-section figures are included in **Chapter 6: Proposed Project - Engineering Features.**

Figure 7-12: 2026 Section 2 and 3 Cross-Section

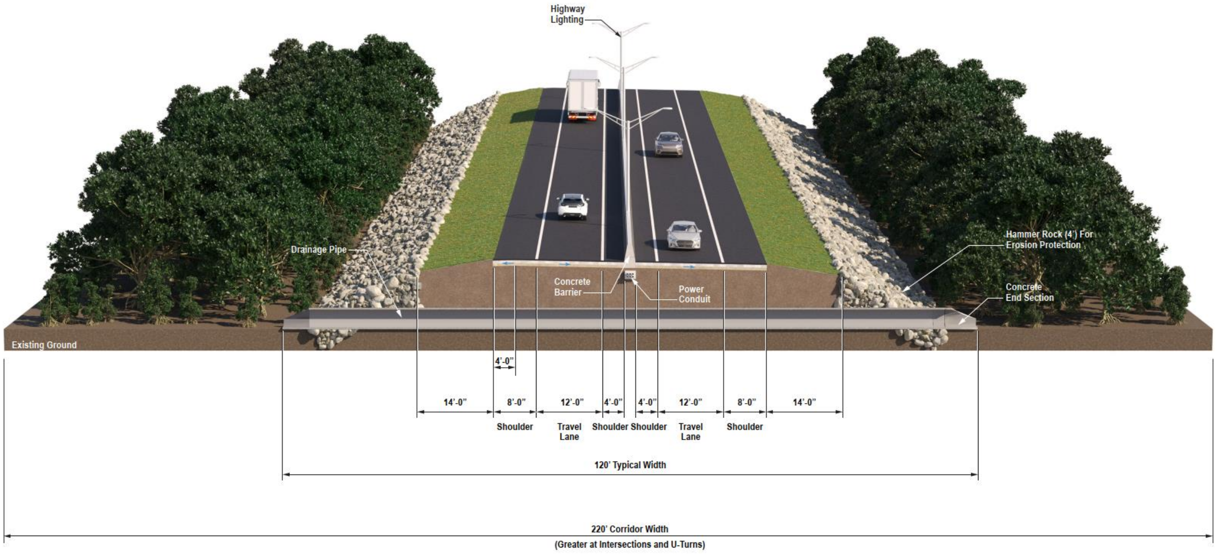


Figure 7-13: 2074 Section 2 and 3 Cross-Section

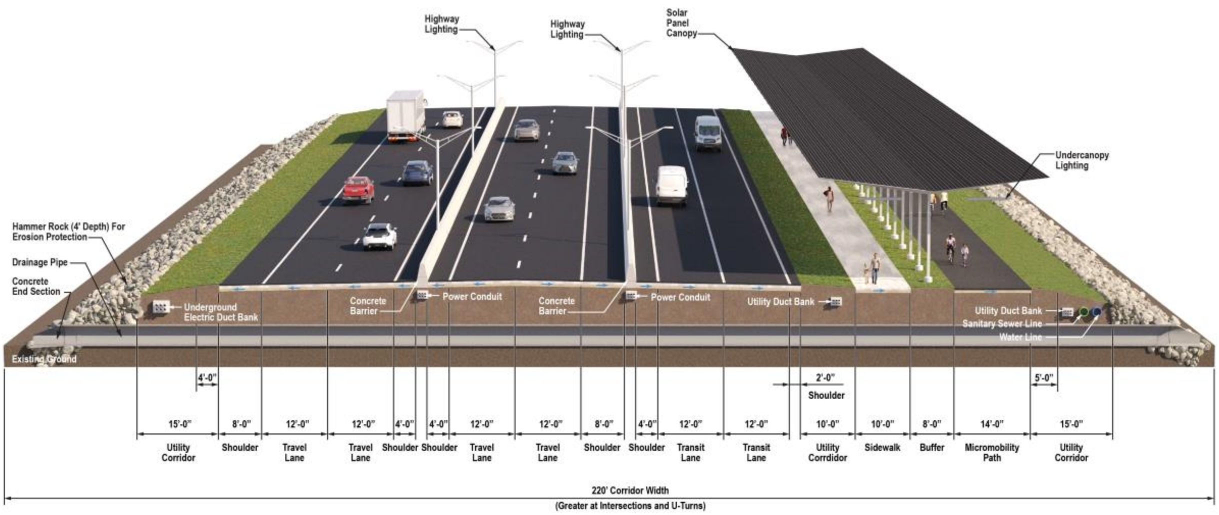


Figure 7-14: 2074 Section 2 and 3 Cross-Section, Bridge Crossings

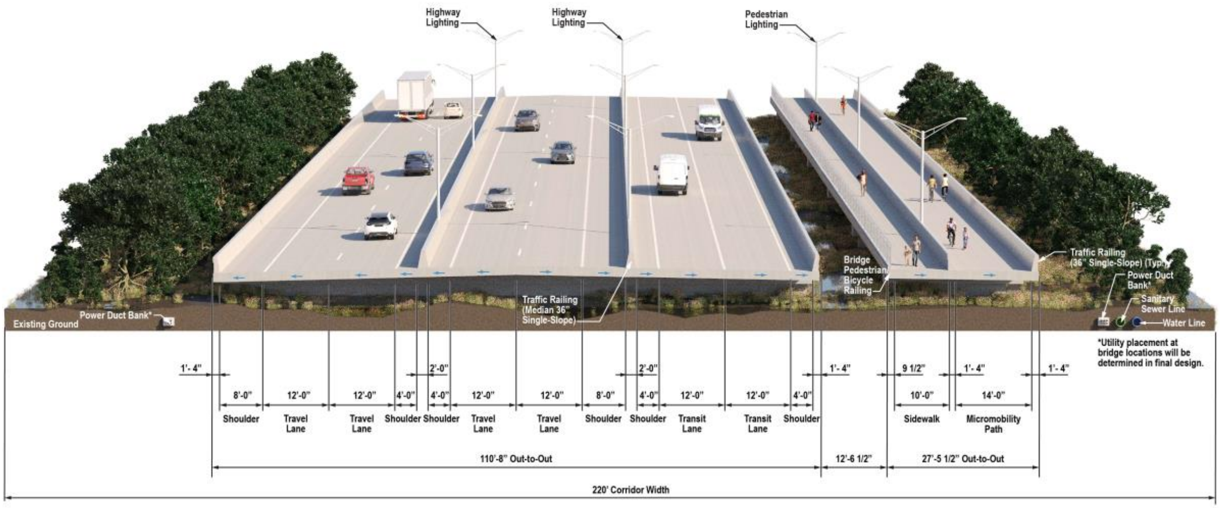


Table 7-2: Proposed Project Section 2 Phased Improvements

Typical Section Components	2026	2036	2046	2074 [d]
Number of Travel Lanes	2	2	4	4
Number of Dedicated Transit Lanes [a]		2	2	2
Sidewalk		✓	✓	✓
Micromobility Path		✓	✓	✓
Utilities [a]		✓	✓	✓
Highway Lighting [a]	✓	✓	✓	✓
Solar Panel Canopy [a b]		✓	✓	✓
Number of Intersection Access Points to the South [c]	6	6	6	6
Number of Intersection Access Points to the North [c]		3	3	3
Number of U-Turn Intersections [c]	2	2	2	2

Table Notes: [a] These features are outside the ambit of the NRA. The NRA will provide the ability for the corridor to accommodate these features.

[b] Solar canopy cannot be installed unless micromobility path is constructed.

[c] Number of intersections excludes roundabout access on each end of the corridor (i.e., EWA at Woodland Drive/Agricola Drive Connector and EWA at Frank Sound Road).

[d] All Component assumptions are the same between 2074 Low, Medium, and High Growth scenarios. Note that construction for all components is expected to be completed by 2060; refer to **Chapter 6: Proposed Project - Engineering Features** for additional details**.**

Table 7-3: Proposed Project Section 3 Phased Improvements

Typical Section Components	2026	2036	2046	2074 [d]
Number of Travel Lanes	2	2	2	4
Number of Dedicated Transit Lanes [a]		2	2	2
Sidewalk		*	✓	✓
Micromobility Path		*	✓	✓
Utilities [a]		✓	✓	✓
Highway Lighting [a]	✓	✓	✓	✓
Solar Panel Canopy [a b]		*	✓	✓
Number of Intersection Access Points to the South [c]	4	4	4	4
Number of Intersection Access Points to the North [c]		4	4	4
Number of U-Turn Intersections [c]	5	5	5	5

Table Notes: [a] These features are outside the ambit of the NRA. The NRA will provide the ability for the corridor to accommodate these features.
[b] Solar canopy cannot be installed unless micromobility path is constructed.
[c] Number of intersections excludes roundabout access on each end of the corridor (i.e., EWA at Woodland Drive/Agricola Drive Connector and EWA at Frank Sound Road).
[d] All Component assumptions are the same between 2074 Low, Medium, and High Growth scenarios. Note that construction for all components is expected to be completed by 2060; refer to **Chapter 6: Proposed Project - Engineering Features** for additional details**.**
[*] Phased as required.

Based on the Shortlist Alternatives Evaluation's interdisciplinary review and coordination with the NRA, the Shortlisted Alternative B3 alignment was selected by Cabinet as the project's preferred alternative. The Proposed Project was ultimately designed as a refined version of original Shortlisted Alternative B3 following additional conceptual design updates and coordination with the NRA. Newly added refinements incorporated as part of the Proposed Project design assumptions include the following:

- Dedicated transit lanes will run south of the corridor's main travel lanes, with construction anticipated by 2036.
- Access point locations were adjusted and converted from full-access roundabouts to partial-access left-in/left-out intersections along the restricted access roadway, excluding the roundabout access points on either end of the corridor (i.e., EWA at Agricola Drive Connector and EWA at Frank Sound Road). For additional details regarding proposed intersection designs, refer to **Section 6.6.9: Intersections.**
    - In 2026, the Proposed Project will consist of ten (10) stop-controlled left-in/left-out access points to the south and seven (7) U-turn points to accommodate vehicle turnarounds. All access points and U-turn locations will include turn lanes to allow vehicles to safely decelerate along the EWA.
    - The Lookout Road intersection is proposed as a Restricted Crossing U-Turn (RCUT) intersection, allowing drivers on Lookout Road to turn left and then make a U-turn to continue to their destination.

- From 2036 onward, the Proposed Project will include an additional seven access points to the north. All ten access points to the south will become signalized to accommodate the dedicated transit lanes running south of the corridor.

For additional details regarding changes to the Proposed Project from the Shortlisted Alternative B3, refer to **Chapter 6: Proposed Project - Engineering Features.**

The Proposed Project corridor alignment and all access points to be constructed by 2026 are illustrated in **Figure 7-15**, while all access points to be constructed by 2036 are illustrated in **Figure 7-16**. The Proposed Project was modelled assuming an appropriate number of travel lanes to meet each future year's projected population growth and roadway capacity requirements. This approach was important to evaluate the evolving needs of Grand Cayman's future traffic demand. The Proposed Project was also modelled using the same design assumptions across all three 2074 land use scenarios to evaluate whether the Proposed Project helps meet CSFs under each land use scenario.

Figure 7-15: 2026 Proposed Project Corridor and Intersection Access Points

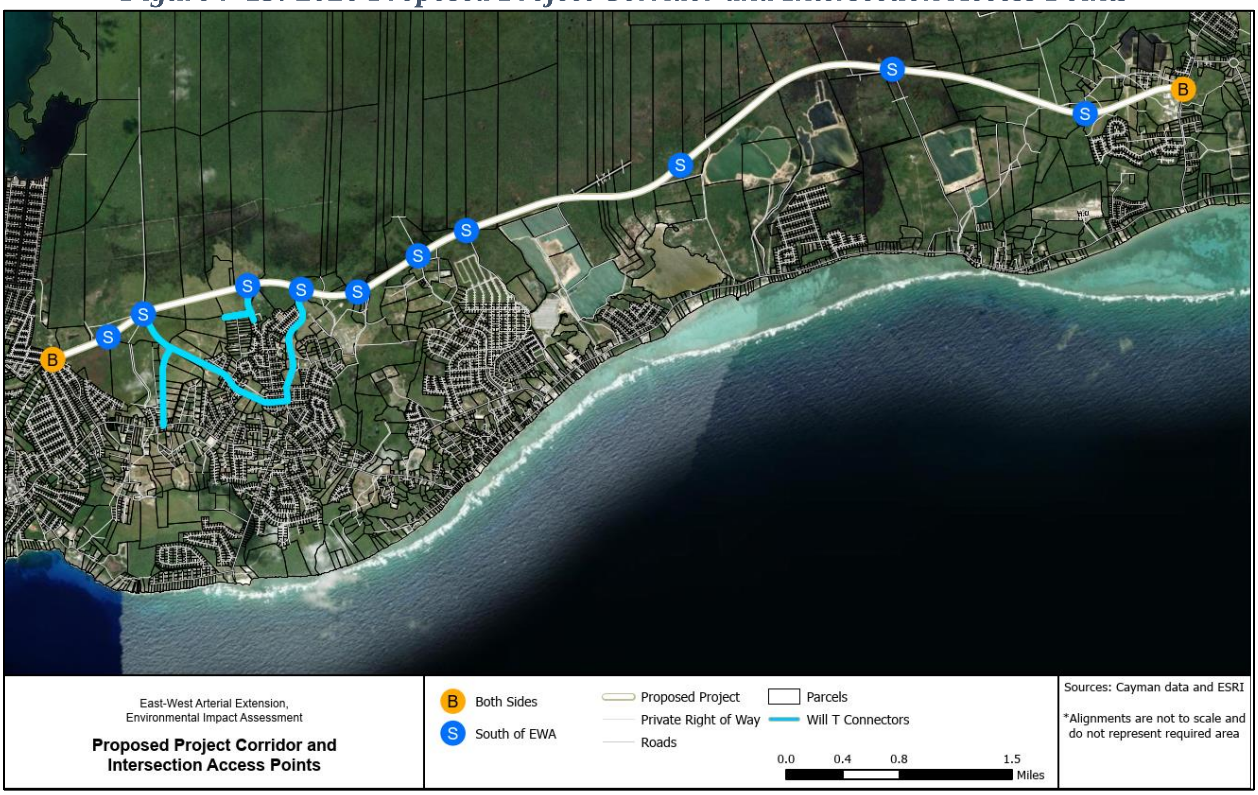


Figure 7-16: 2036, 2046, and 2074 Proposed Project Corridor and Intersection Access Points

7.4.2 Description and Assessment of Impacts

The assessment methodology of transportation and mobility impacts discussed in this chapter is based on the CSFs that were developed based on the ToR for the EWA Extension. The CSFs are objectives that are vital to the project's success, representing the main goals that the Proposed Project aims to achieve. **Table 7-4** provides a list of the CSFs that will be further assessed in this chapter. The following sections quantitatively and qualitatively evaluate how the Proposed Project addresses each of the CSFs. An overall summary of the project's anticipated impacts relating to each CSF is provided in **Table 7-20,** including an assessment of how effectively the Proposed Project would achieve each CSF. The Proposed Project was assessed using the Future No-Build conditions as a basis for comparison.

Table 7-4: Critical Success Factors List – Transportation and Mobility Evaluation

Criteria	Target
a. **Alternate Routes:** Create an alternative travel route to the existing two-lane Bodden Town Road	Provide an alternative roadway facility to accommodate travel in the event of a roadway closure (**Section 7.4.4: Resiliency)**
b. **Existing Roadway Resiliency:** Improve resiliency of the existing roadway travel route between North Side/East End and George Town/West Bay.	Improve resiliency of the travel route to flooding from sea level rise, storm surge, wave overtopping, and rainfall (**Section 7.4.4: Resiliency**)
c. **Future Traffic Demand:** Support current and future traffic demand.	Provide travel lanes necessary to accommodate projected trips/vehicles (**Section 7.4.3.2: Screenline Volumes** and **Section 7.4.3.3: District-to-District Work Trips**) Provide controlled access points to enter roadway facility (**Section 7.4.6: Intersection Delay**)
d. **Commuter Travel Times:** Improve travel time between North Side/East End and George Town/West Bay	Improve projected travel time between North Side/East End and George Town/West Bay (**Section 7.4.5.1: Study Area Travel Time** and **Section 7.4.5.2: Travel Time to Key Destinations in George Town/West Bay**)
e. **Utilities:** Accommodate utility expansion (electricity, fibre, water, central sewage) *	Establish area adjacent to roadway to provide for utility needs. (Discussion of utilities is included in **Chapter 6: Proposed Project - Engineering Features**)
f. **Public Transit Access:** Provide opportunity to safely accommodate and expand public transportation *	Establish public transportation facilities and improve bus travel time reliability. (Discussion of potential public transportation opportunities is included in **Chapter 6: Proposed Project - Engineering Features** and **Chapter 8: Socio-Economics**)
g. **Tourist Travel Times:** Reduce tourism travel time between North Side/East End and George Town	Reduce travel times between Owen Roberts International Airport and the North Side (**Section 7.4.5.2: Travel Time to Key Destinations in George Town/West Bay**) Reduce travel time between Grand Cayman Cruise Port (George Town Cruise Port) and Bodden Town/North Side/East End (**Section 7.4.5.3: Tourist Travel Times**)
h. **Safety:** Improve safe vehicular travel by reducing roadway conflict points	Reduce the number of Cross Street Intersections along the primary east-west corridor (**Section 7.4.7: Safety**) Reduce the number of Driveway Access Points along the primary east-west corridor (**Section 7.4.7: Safety**)
i. **Pedestrian and Bicycle Access:** Provide opportunity for enhanced and safe pedestrian and bicycle travel	Establish dedicated pedestrian and bicycle facilities adjacent to vehicular travel lanes (**Section 7.4.8: Multimodal Access**)

**These criteria are to provide opportunities to accommodate these features. It is outside the ambit of the NRA to provide utilities or public transportation.*

7.4.3 Traffic Demand

Supporting current and future traffic demand is a CSF for the Proposed Project. Current residents of North Side and East End experience widespread congestion on the existing coastal road, and these conditions are expected to worsen as population continues to grow, highlighting the need for additional roadway infrastructure. **Figure 7-5** shows existing morning peak hour congestion along westbound Shamrock Road near Will T Road that was observed in February 2023, illustrating the congestion issues prevalent in the study area.

7.4.3.1 Variable Demand Model

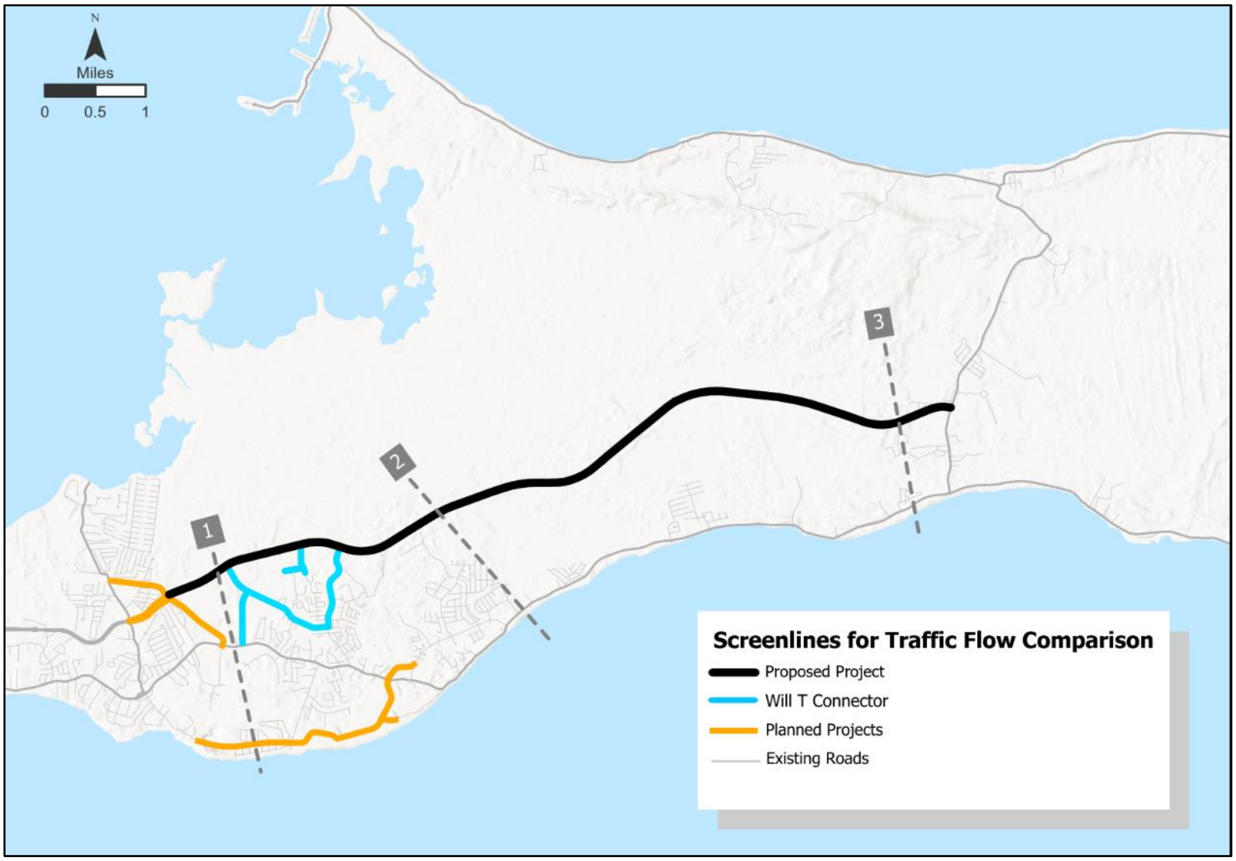
Induced traffic refers to the phenomenon where roadway infrastructure projects intended to alleviate existing traffic congestion ultimately lead to a rise in overall vehicle trips. As an example, if a new road is built to alleviate existing congestion and accommodate additional vehicles, more people may choose to drive longer distances. This is due to improved accessibility to key destinations, such as access to jobs, that would be too difficult to reach under the No-Build conditions.

When modelling the Proposed Project, the GCM captures the induced traffic anticipated because of the EWA Extension by using a “variable demand” approach that reflects how travel conditions may change in response to the additional roadway capacity, rather than using a “fixed demand” approach that would assume the same travel patterns between the Future No-Build and the Proposed Project. According to WebTAG Unit M1-1 *Principles of Modelling and Forecasting*, the fixed demand approach is deemed “inadequate for transport schemes aimed at resolving congestion.” Instead, variable demand models are more appropriate to best capture variations in demand as travel opportunities change. Therefore, the results discussed throughout this document reflect the potential induced demand generated by the EWA Extension, and traffic volumes ultimately differ between the Future No-Build and Proposed Project.

7.4.3.2 Screenline Volumes

A screenline is used to illustrate all traffic at a specific location using all available routes. Screenlines are drawn across multiple parallel routes in a roadway network to compare total traffic flows at a given location. Three screenlines were evaluated at key corridor locations: (1) east of Woodland Drive/Agricola Drive Connector, (2) east of Lookout Road, and (3) west of Frank Sound Road to capture how traffic volumes are impacted by the Proposed Project as shown in **Figure 7-17**.

Figure 7-17: Screenlines for Traffic Flow Comparison



Two-way screenline volumes comparisons are displayed for future analysis years 2026 through 2074 in **Figure 7-18** through **Figure 7-20**, indicating the anticipated volume traveling in both directions across the 6:00 to 7:00 AM and 5:00 to 6:00 PM peak hours. For each evaluation year, the screenline volumes reflect how people are expected to travel differently in response to the impact of the Proposed Project on accessibility.

Compared to Future No-Build conditions, the Proposed Project is consistently forecasted to accommodate more east-west travel through the study area across all future analysis years, while simultaneously reducing traffic volumes along the existing roadways of Shamrock Road and Bodden Town Road as drivers divert to the EWA Extension. The Proposed Project will provide a higher-speed, higher-capacity roadway compared to the existing coastal roadway, diverting traffic onto the Proposed Project and improving the transportation supply available to residents in the eastern districts of Bodden Town, North Side, and East End. The Proposed Project is anticipated to serve higher peak traffic demand, increasing peak hour traffic flows through the study area by 7 to 17% across the three screenline locations during 2026, 2036, 2046, 2074 Low Growth, and 2074 Medium Growth conditions. Under 2074 High Growth conditions, the Proposed Project is anticipated to add much-needed capacity to the highly congested traffic system, accommodating up to 97% more vehicles.

Figure 7-18: Screenline 1, Total AM/PM Peak Hour Volumes (Two-way)

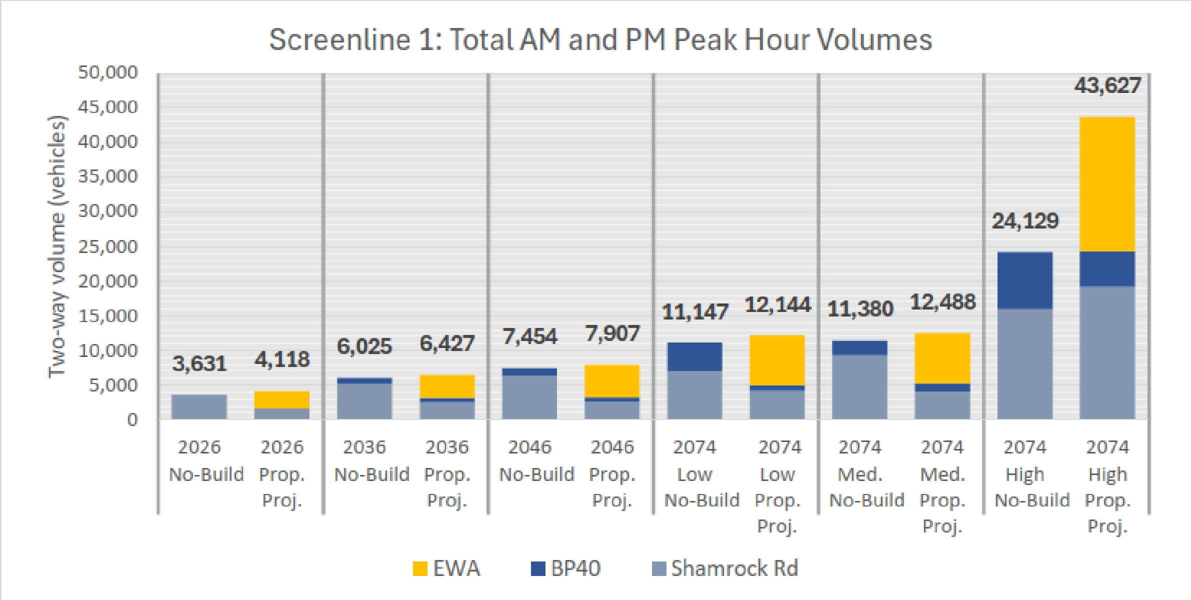


Table notes: Screenline locations are shown in **Figure 7-17.** Volumes reflect how people are expected to travel in response to changing accessibility, likely making longer-distance trips as access improves.

Figure 7-19: Screenline 2, Total AM/PM Peak Hour Volumes (Two-way)

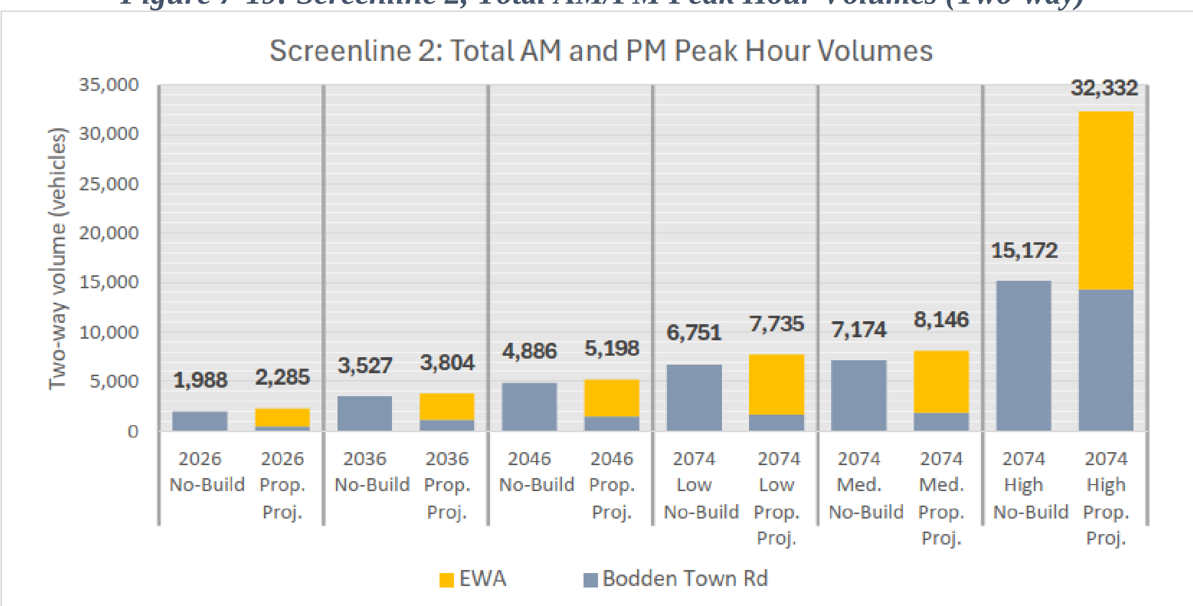


Table notes: Screenline locations are shown in **Figure 7-17.** Two-way volumes reflect how people are expected to travel in response to changing accessibility, likely making longer-distance trips as access improves.

Figure 7-20: Screenline 3, Total AM/PM Peak Hour Volumes (Two-way)

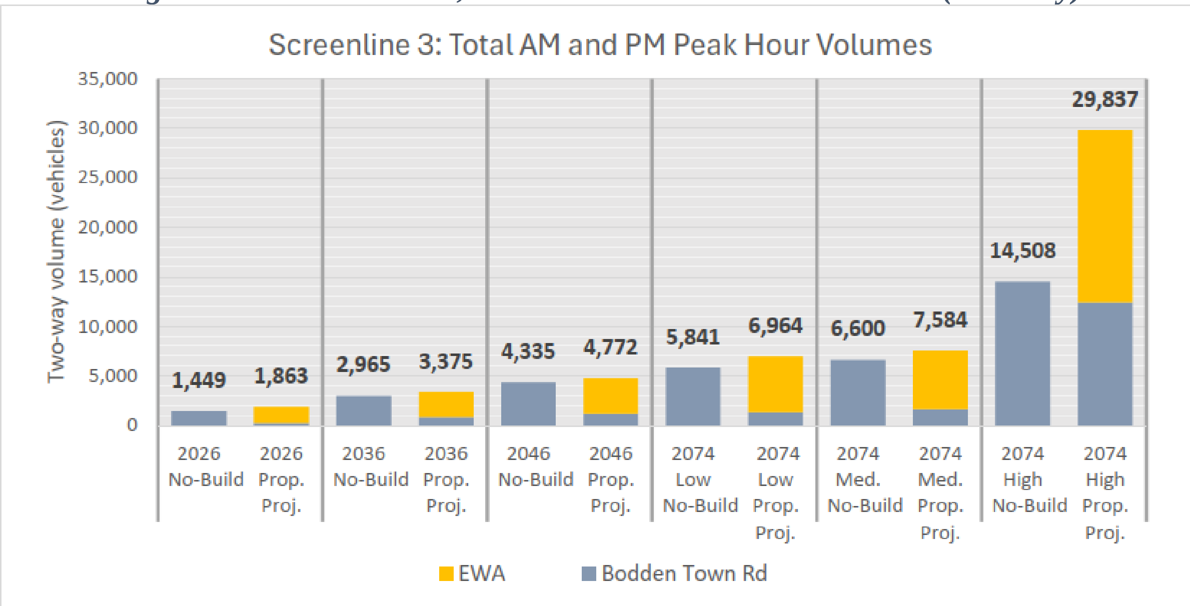


Table notes: Screenline locations are shown in **Figure 7-17.** Two-way volumes reflect how people are expected to travel in response to changing accessibility, likely making longer-distance trips as access improves.

District-to-District Work Trips

Another way to illustrate the Proposed Project's impact on supporting current and future traffic demand is to examine the anticipated changes in district-to-district travel patterns, such as whether farther commutes to key employment centres in George Town become more accessible to people residing in North Side and East End. The large majority of Grand Cayman's employment opportunities currently exist in George Town and West Bay, as shown by the distribution of population and employment centres in **Figure 7-4**. For residents of North Side and East End, the result is that they must endure a lengthy commute to access jobs in George Town.

By expanding roadway capacity, the Proposed Project is expected to improve access to employment opportunities in George Town and West Bay. The Proposed Project is anticipated to improve commute times between the east and west districts compared to Future No-Build conditions, thereby increasing transportation availability and supporting longer-distance travel that was previously limited by heavy congestion. Such demand shifts are evident in **Figure 7-21** and **Figure 7-22** which show district-to-district work-related trips from the eastern districts of North Side and East End during the morning commute. Trip numbers between the eastern and western districts were calculated from home to work (east to west) during the morning peak.

Figure 7-21: AM District-to-District Work Trips from North Side

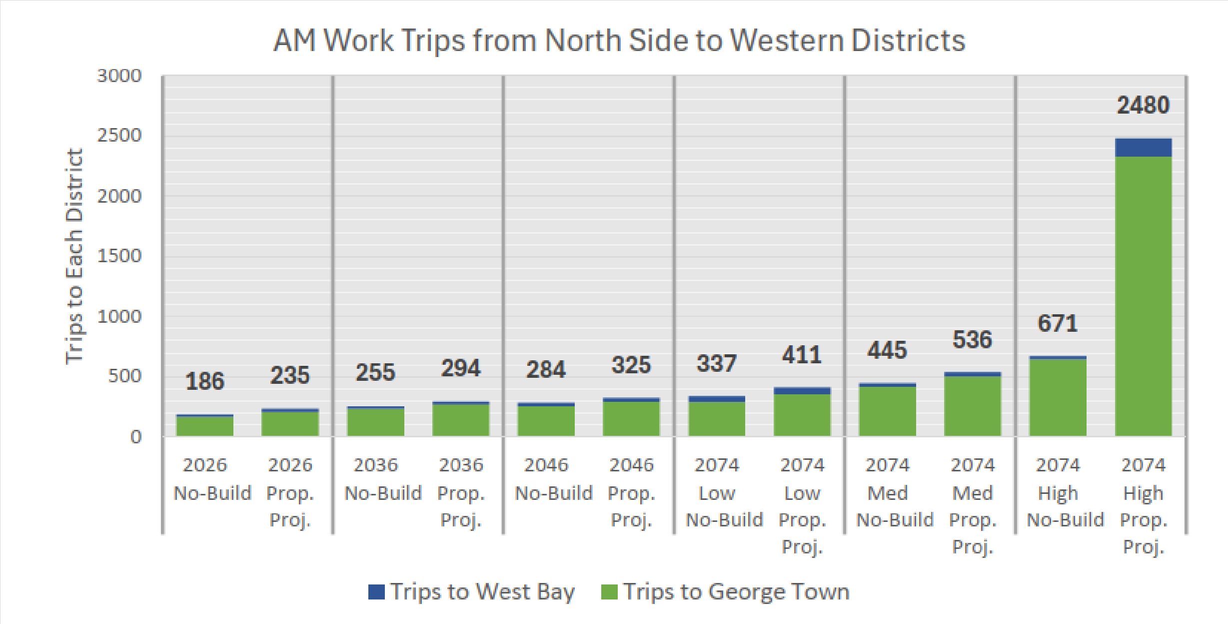
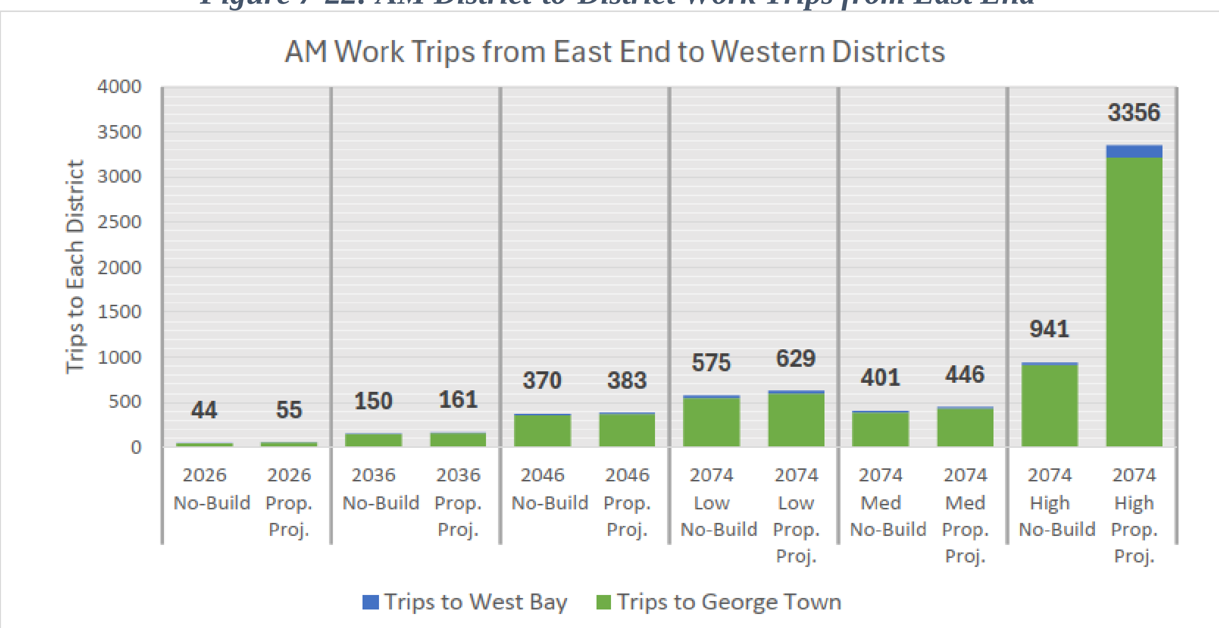


Figure 7-22: AM District-to-District Work Trips from East End



The Proposed Project is anticipated to improve the accessibility of longer-distance work trips destined for George Town as shown in **Figure 7-21** and **Figure 7-22**, demonstrating that access to those employment opportunities become more viable with the construction of the EWA Extension. The Proposed Project is also expected to exhibit the following changes in work travel patterns:

- AM work trips originating from North Side traveling to western districts are anticipated to increase on average by 20% across future analysis years 2026, 2036, 2046, 2074 Low Growth, and 2074 Medium Growth, indicating improved employment access for North Side residents due to the Proposed Project.

- AM work trips originating from East End traveling to western districts are anticipated to increase on average by 11% across future analysis years 2026, 2036, 2046, 2074 Low Growth, and 2074 Medium Growth, indicating improved employment access for East End residents due to the Proposed Project.

- Due to differing assumptions about employment growth, the 2074 Low Growth conditions are anticipated to result in more work trips between eastern and western districts than the 2074 Medium Growth conditions. As discussed in **Section 7.3.5.1: 2074 Land Use Scenarios**, the Medium Growth conditions assume a larger increase in employment opportunities within Bodden Town, North Side, and East End, allowing residents of eastern districts to seek shorter commutes to local jobs rather than traveling longer distances to George Town or West Bay. Conversely, the Low Growth scenario assumes relatively modest employment growth in eastern districts, likely increasing the number of work trips to jobs primarily available in western districts. Ultimately, the Proposed Project continues to improve job opportunities for both the Low Growth and Medium Growth conditions.

- Under 2074 High Growth conditions, the Proposed Project is forecasted to increase work trips from eastern districts to western districts by up to 270%, indicating that the Proposed Project is anticipated to add much-needed capacity to the highly congested traffic system.

7.4.4 Resiliency

Resiliency is a key factor in determining the Proposed Project's success, particularly creation of an alternate travel route to the existing two-lane coastal roadway, as well as enhanced resiliency of the existing roadway travel route between North Side/East End and George Town/West Bay.

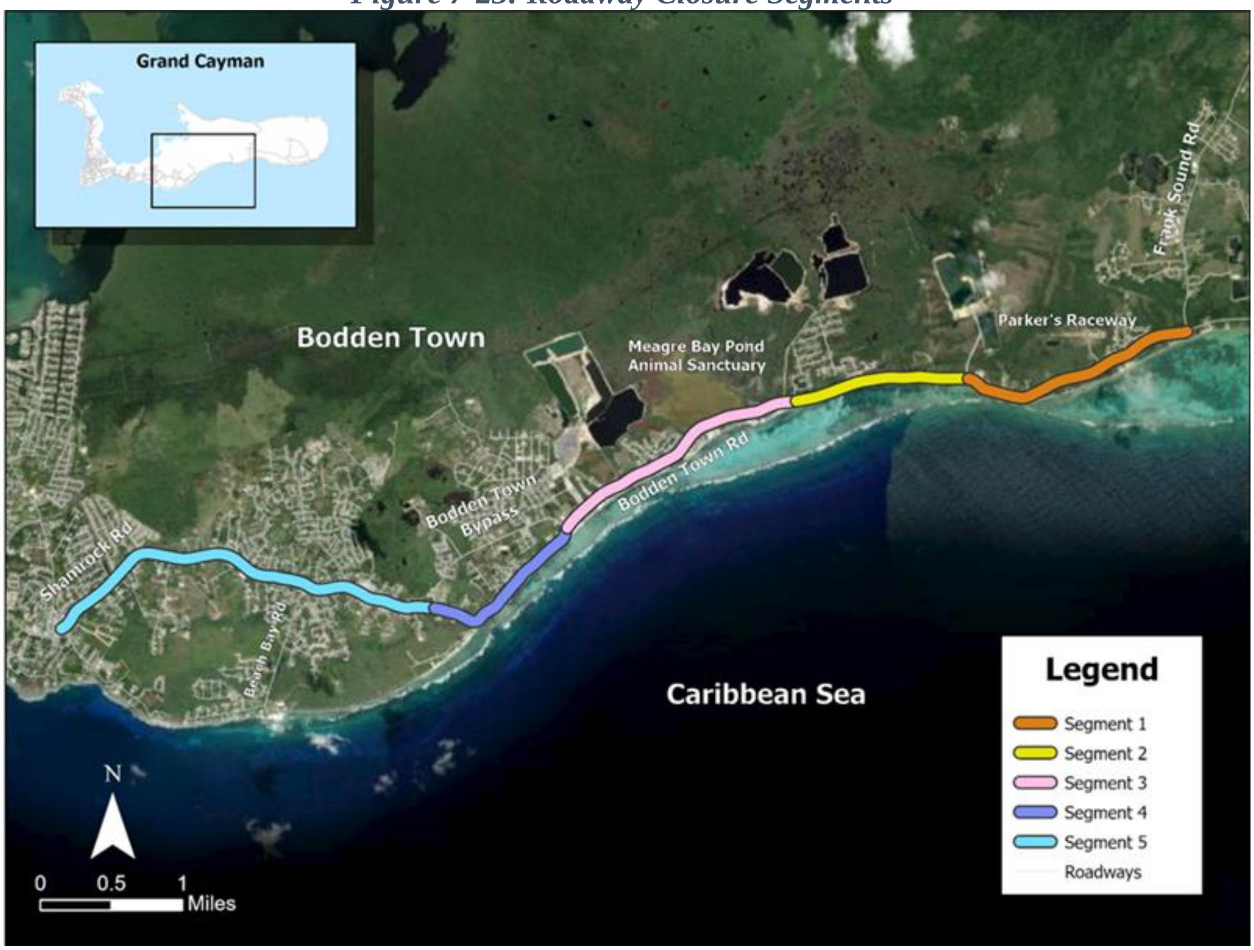
7.4.4.1 Road Closures and Alternative Routes

Shamrock Road and Bodden Town Road currently provide the sole route for traffic between George Town/West Bay and North Side/East End. This lack of alternative routes means that incidents such as crashes, storms, flooding, or fallen debris can cause roadway closures that completely cut off east-west traffic, leaving thousands stranded for hours or even days. Although some medical services are available in the eastern districts at the Health City Cayman Islands Hospital (also known as Shetty Hospital) in East End and at local clinics in each district, critical emergency services from the HSA Hospital in George Town may become inaccessible to eastern districts during natural disasters. It is worth noting that the HSA Hospital in George Town is the only authorized provider of 24-hour Accident and Emergency Services in Grand Cayman. Eastern residents may also find themselves cut off from jobs, schools, the cargo port, the airport, and other resources located in western districts during planned or unplanned road closures.

To evaluate the resiliency of the Proposed Project, the impacts of a road closure were assessed for five segments along Shamrock Road and Bodden Town Road, as shown in **Figure 7-23**.

- Segment 1: Frank Sound Road to Betty Bay Pond Driveway
- Segment 2: Betty Bay Pond Driveway to Long Fellow Road
- Segment 3: Long Fellow Road to Bodden Town Bypass
- Segment 4: Bodden Town Bypass to Condor Road
- Segment 5: Condor Road to Hirst Road

Figure 7-23: Roadway Closure Segments



The eastern populations impacted under the Future No-Build and Proposed Project conditions were calculated per segment in **Table 7-5**, showing the projected population that will lose access to western districts when different roadway segments become unavailable. By providing an alternate route parallel to the existing Shamrock Road and Bodden Town Road, the Proposed Project provides 100% resiliency to the system across all future analysis years – that is, there are no losses to east-west travel due to a closure along the existing coastal roads. Depending on which segment becomes unavailable, the Proposed Project provides a resilient alternate route for between 4% to 12% of the island's population in 2026; by 2074 Medium Growth conditions, those numbers increase to anywhere from 8% to 15% of the population.

Table 7-5: Population Losing Access Due to Road Closure by Year Under Future No-Build

Unavailable Segment	2026		2036		2046		2074 Low		2074 Medium		2074 High	
	No-build	Proposed Project	No-build	Proposed Project	No-build	Proposed Project	No-build	Proposed Project	No-build	Proposed Project	No-build	Proposed Project
Segment 1	3,082	0	5,840	0	9,893	0	14,106	0	10,893	0	65,550	0
Segment 2	4,056	0	6,929	0	10,982	0	15,661	0	14,515	0	75,654	0
Segment 3	4,431	0	7,304	0	11,357	0	16,036	0	15,356	0	80,317	0
Segment 4	7,882	0	11,135	0	15,730	0	22,136	0	19,729	0	97,811	0
Segment 5	8,820	0	9,774	0	9,774	0	13,665	0	14,772	0	32,768	0

Table notes: Impacted population for Segment 5 is the same for 2036 and 2046 because no additional developments are planned along this segment between 2036 and 2046. Additionally, 2074 Low Growth's impacted population for Segments 1, 2, 3, and 4 are greater than 2074 Medium Growth due to the locations of population growth assumed in the Land Use Charrette (see **Figure 7-9** and **Figure 7-10**).

7.4.4.2 Existing Coastal Roadway Resiliency

Shamrock Road and Bodden Town Road provide access to several residential neighbourhoods, schools, and businesses. It is vital to improve the existing coastal road's resiliency to ensure its continued functionality in the event of crashes or other unforeseen traffic incidents.

The EWA Extension will be designed to modern standards, providing a safer facility and likely diverting traffic away from the existing roadways. As a result, Shamrock Road and Bodden Town Road will likely experience less traffic once the Proposed Project is constructed, proportionally reducing the number of crashes and other incidents that could disrupt traffic flow. The Proposed Project is therefore expected to improve the resiliency and reliability of the existing coastal roadway while shifting drivers to the safer EWA Extension route. The forecasted volumes along Shamrock Road and Bodden Town Road are summarized in **Table 7-6** based on the screenline locations shown in **Figure 7-17**, and an overall percent change from the Future No-Build was calculated for the Proposed Project.

Table 7-6: Forecasted Roadway Screenline Volumes (Two-way)

Screenline	Road	2026	2036	2046	2074 Low	2074 Medium	2074 High
Future No-Build							
1	Shamrock Rd	3,631	5,154	6,315	6,996	9,325	15,940
2	Bodden Town Rd	1,988	3,527	4,886	6,751	7,174	15,172
3	Bodden Town Rd	1,449	2,965	4,335	5,841	6,600	14,508
Average Two-Way Volume		**2,356**	**3,882**	**5,179**	**6,529**	**7,700**	**15,207**
Proposed Project							
1	Shamrock Rd	1,562	2,479	2,597	4,133	4,028	19,123
2	Bodden Town Rd	460	1,136	1,483	1,645	1,843	14,321
3	Bodden Town Rd	232	832	1,208	1,358	1,632	12,438
Average Two-Way Volume		**751**	**1,482**	**1,762**	**2,379**	**2,501**	**15,294**
% Change from No-Build		**-68%**	**-62%**	**-66%**	**-64%**	**-68%**	**1%**

Table note: Screenline locations are shown in **Figure 7-17.**

The Proposed Project is anticipated to decrease traffic volumes on the existing coastal roads of Shamrock Road and Bodden Town Road by at least 60% in future analysis years 2026, 2036, 2046, 2074 Low Growth, and 2074 Medium Growth (**Table 7-6**). Under 2074 High Growth conditions, the Proposed Project is forecasted to have traffic volumes comparable to the Future No-Build conditions. The additional demand created by the High Growth Scenario will significantly exceed the capacity of the transportation system outside of the study area regardless of the implementation of the Proposed Project. Because the High Growth scenario is expected to generate such extreme congestion, the Proposed Project is likely to accommodate additional traffic along the new EWA without shifting many drivers off the existing coastal road.

7.4.5 Travel Time

Improving travel times between the eastern districts of Bodden Town/North Side/East End and the western districts of George Town/West Bay is a CSF for the Proposed Project. Currently, residents of North Side and East End endure extended commutes along the existing roadway. **Figure 7-5** shows existing morning peak hour congestion along westbound Shamrock Road near Will T Road that was observed in February 2023, illustrating the congestion issues prevalent in the study area. These conditions are expected to worsen as Grand Cayman's population continues to grow, underscoring the need for additional roadway infrastructure. The following sections will discuss anticipated travel time impacts of the Proposed Project at key locations compared to Future No-Build conditions during peak commute hours from 6:00 to 7:00 AM and 5:00 to 6:00 PM.

7.4.5.1 Study Area Travel Time

The GCM was used to evaluate travel times along the existing coastal road and proposed EWA to capture localized congestion effects for residents of Bodden Town. The anticipated travel times between Frank Sound Road and Hirst Road were assessed for the AM westbound direction (**Figure 7-24** and **Figure 7-25**) and PM eastbound direction (**Figure 7-26** and **Figure 7-27**), where the provided travel times include intersection delay for the EWA and Hirst Road intersection. This comparison illustrates improvements in travel times along the available route(s) that Bodden Town, North Side, and East End residents would be using within the study area, with the area in blue representing the overall travel time savings provided by the Proposed Project.

Under Future No-Build conditions, residents traverse the existing Bodden Town Road and Shamrock Road between Frank Sound Road and the Agricola Drive Connector, at which point they can choose to either: 1.) continue on Shamrock Road between the Agricola Drive Connector and Hirst Road or 2.) use the Agricola Drive Connector and Section 1 of the EWA extension.

When the Proposed Project is constructed, residents can choose to traverse either available route: 1.) Bodden Town Road and Shamrock Road or 2.) EWA Extension, between Frank Sound Road and Hirst Road, depending on their origin or destination within Bodden Town.

Figure 7-24: AM Westbound Travel Time (minutes) from Frank Sound Road to Hirst Road via EWA

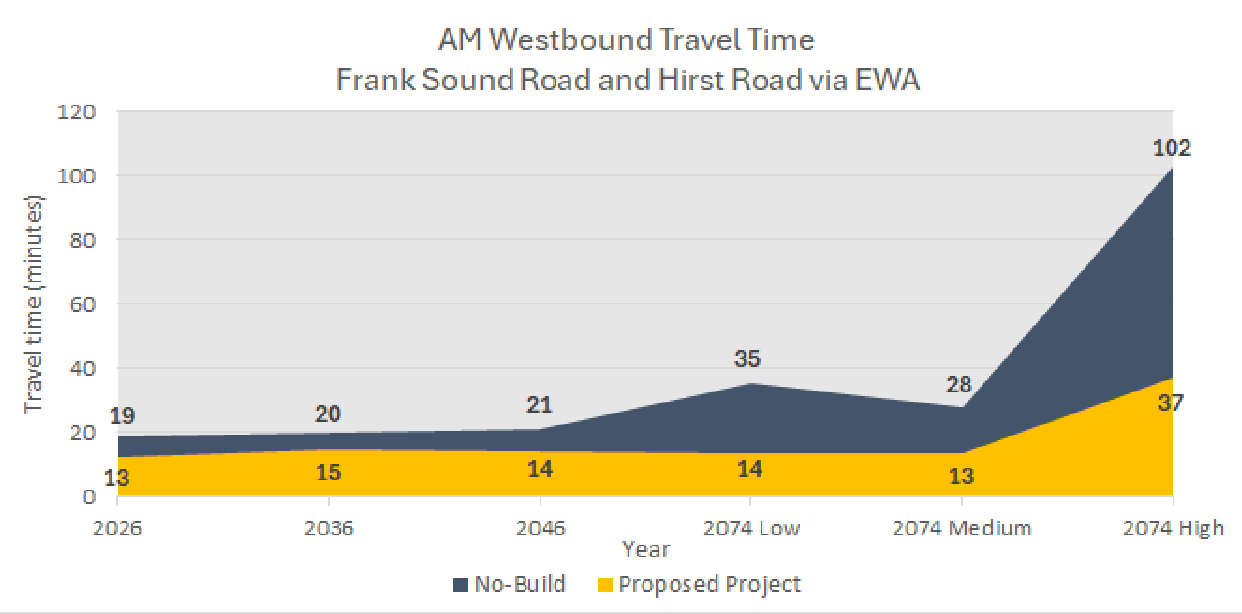


Table note: 2074 Low Growth's anticipated travel times are greater than 2074 Medium Growth due to where employment and population growth were assumed for these scenarios (see **Figure 7-9** and **Figure 7-10**, as well as a comparison of employment and population assumptions discussed in **Section 7.3.5.1: 2074 Land Use Scenarios**).

Figure 7-25: AM Westbound Travel Time (minutes) from Frank Sound Road to Hirst Road via Shamrock Road/Bodden Town Road

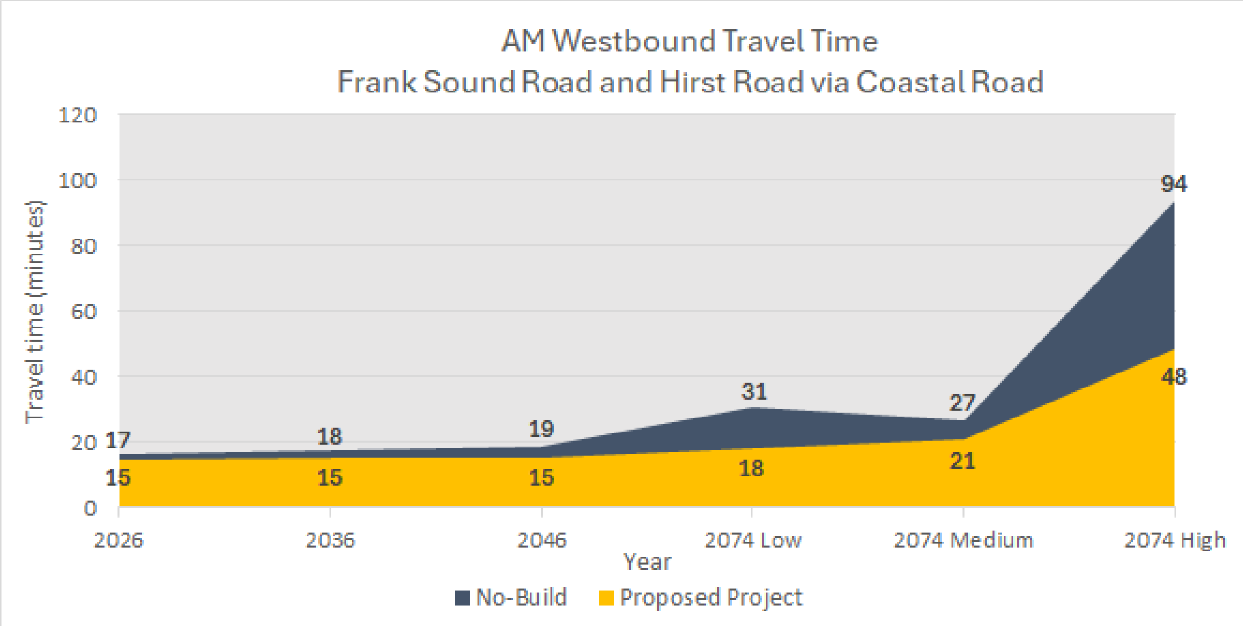


Table note: 2074 Low Growth's anticipated travel times are greater than 2074 Medium Growth due to where employment and population growth were assumed for these scenarios (see **Figure 7-9** and **Figure 7-10**, as well as a comparison of employment and population assumptions discussed in **Section 7.3.5.1: 2074 Land Use Scenarios**).

Figure 7-26: PM Eastbound Travel Time (minutes) from Hirst Road to Frank Sound Road via EWA

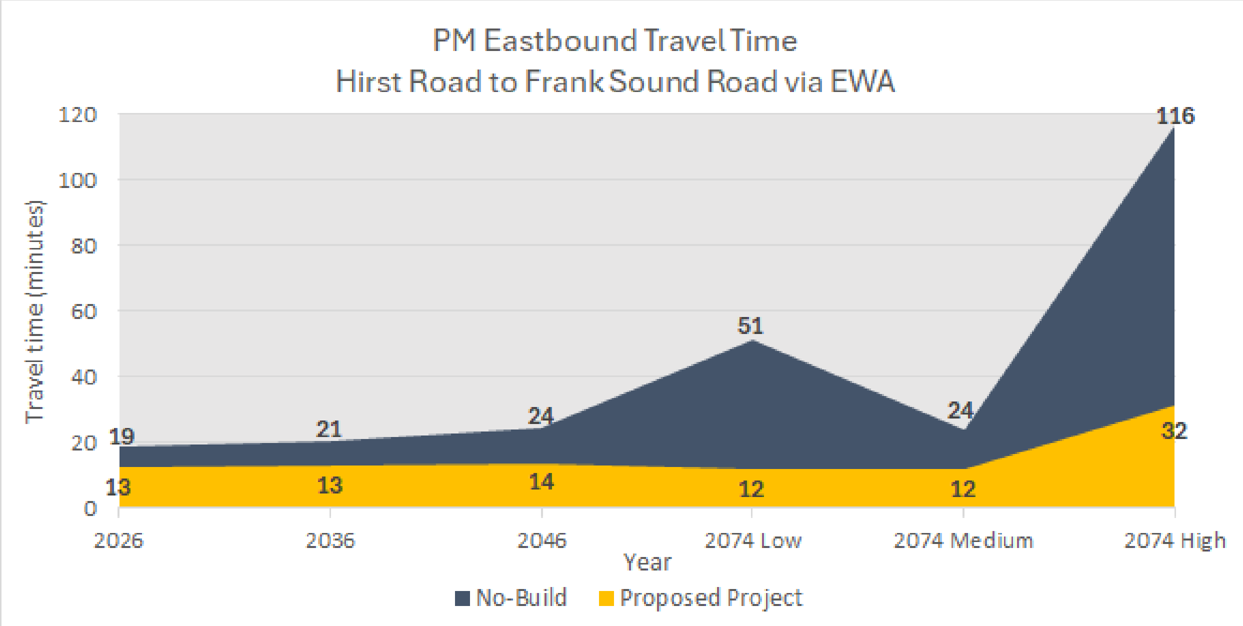


Table note: 2074 Low Growth's anticipated travel times are greater than 2074 Medium Growth due to where employment and population growth were assumed for these scenarios (see **Figure 7-9** and **Figure 7-10**, as well as a comparison of employment and population assumptions discussed in **Section 7.3.5.1: 2074 Land Use Scenarios**).

Figure 7-27: PM Eastbound Travel Time (minutes) from Hirst Road to Frank Sound Road via Shamrock Road/Bodden Town Road

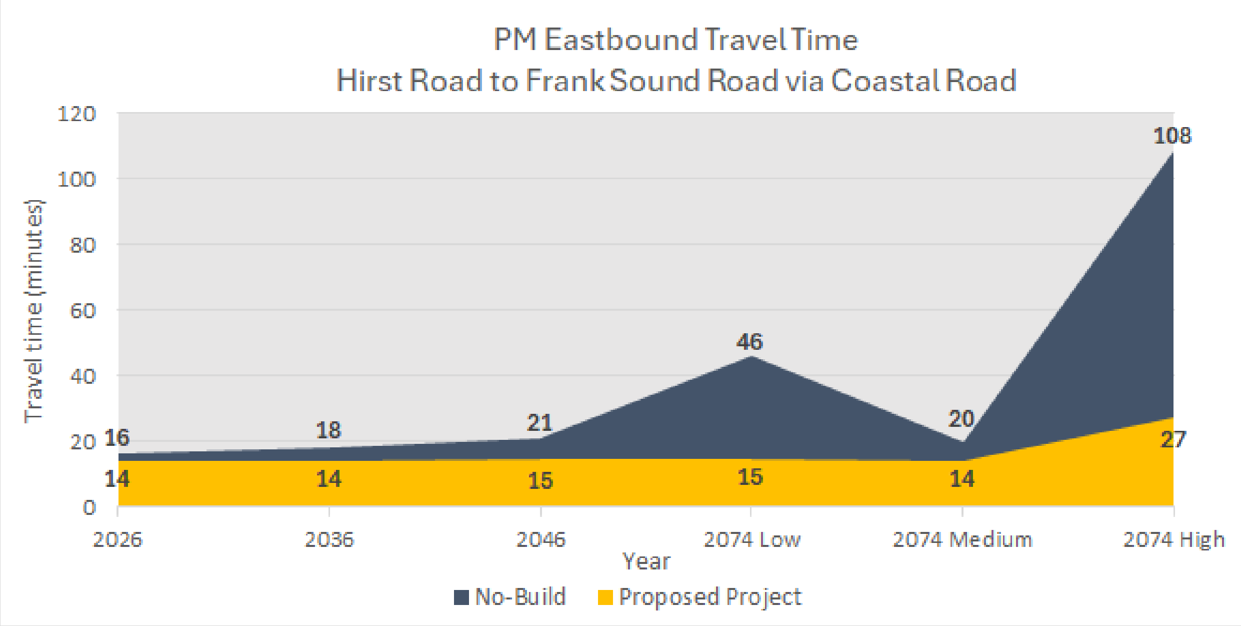


Table note: 2074 Low Growth's anticipated travel times are greater than 2074 Medium Growth due to where employment and population growth were assumed for these scenarios (see **Figure 7-9** and **Figure 7-10**, as well as a comparison of employment and population assumptions discussed in **Section 7.3.5.1: 2074 Land Use Scenarios**).

As shown in **Figure 7-24** to **Figure 7-27,** the AM westbound and PM eastbound commutes between Frank Sound Road and Hirst Road are expected to worsen as the population continues to grow between 2026 and 2074 conditions. Compared to No-Build conditions, the Proposed Project is expected to improve travel times along the existing coastal road by diverting traffic onto the EWA Extension and reducing through traffic along the coastal road, with travel time savings represented by the blue area in **Figure 7-24** to **Figure 7-27**. The Proposed Project improves the anticipated travel time between Frank Sound Road and Hirst Road (approximately 8.5 mi) as follows:

- The projected AM westbound commute travel time along the EWA improves by as little as 5 minutes in 2036 and by up to 65 minutes under 2074 High Growth conditions (**Figure 7-24)**. The projected AM westbound commute along the coastal roadway of Shamrock Road and Bodden Town Road improves by as little as 2 minutes in 2026 and by up to 46 minutes under 2074 High Growth conditions (**Figure 7-25)**.

- The projected PM eastbound commute travel time along the EWA improves by as little as 6 minutes in 2026 and by up to 84 minutes under 2074 High Growth conditions (**Figure 7-26**). The projected PM eastbound commute along the coastal roadway of Shamrock Road and Bodden Town Road improves by as little as 2 minutes in 2026 and by up to 81 minutes under 2074 High Growth conditions (**Figure 7-27**).

- Due to differing employment and population growth assumptions, the 2074 Low Growth conditions are anticipated to experience higher travel times than in 2074 Medium Growth conditions. As discussed in **Section 7.3.5.1: 2074 Land Use Scenarios**, the Medium Growth conditions assume a larger increase in employment within Bodden Town, North Side, and East End, allowing eastern district residents to seek shorter commutes to local job opportunities. The Medium Growth scenario also assumes lower populations within Bodden Town and East End than the Low Growth conditions. As a result, the Medium Growth scenario is expected to experience shorter travel times within the study area compared to the Low Growth scenario due to the improved employment opportunities assumed within eastern districts as well as lower total population assumed in these areas. Ultimately, the Proposed Project continues to improve travel times for both the Low Growth and Medium Growth conditions compared to Future No-Build conditions.

The Proposed Project provides travel time benefits across all analysis years compared to Future No-Build conditions, but these benefits grow in significance as the traffic demand increases, as shown by the increased travel time savings projected under 2074 conditions. The Proposed Project also provides benefits from a travel time reliability perspective, as evidenced by travel times remaining relatively consistent between 2026 and the 2074 Low and Medium Growth scenarios.

7.4.5.2 Travel Time to Key Destinations in George Town/West Bay

Travel times were evaluated between eastern districts and key western destinations such as the George Town Hospital, Camana Bay, Walkers Road schools, and Owen Roberts International Airport (**Table 7-7**). These travel times were calculated to/from North Side and East End by averaging AM peak hour westbound travel times and PM peak hour eastbound travel times for the entire district to/from each key destination, and similarly calculated for East Bodden Town by averaging travel times across a selection of zones located near Lookout Road. The Proposed Project was assessed using the Future No-Build conditions as a basis for comparison.

Table 7-7: Combined Average Travel Times, AM Westbound and PM Eastbound (minutes)

Origin	Destination	2026		2036		2046		2074 Low		2074 Medium		2074 High	
		No-Build	Proposed Project	No-Build	Proposed Project	No-Build	Proposed Project	No-Build	Proposed Project	No-Build	Proposed Project	No-Build	Proposed Project
North Side	George Town Hospital	54	47	68	55	66	55	98	60	83	61	227	109
	Camana Bay	54	48	68	51	68	56	100	60	86	64	230	112
	Walkers Road Schools	49	42	72	54	72	57	103	67	85	66	234	124
	Owen Roberts Airport	53	47	68	51	68	53	96	54	81	60	222	105
East End	George Town Hospital	56	52	59	58	63	60	91	63	75	64	198	110
	Camana Bay	56	52	60	57	65	62	95	66	80	69	202	112
	Walkers Road Schools	50	47	64	62	70	65	97	74	79	72	202	126
	Owen Roberts Airport	55	51	59	57	64	59	90	61	75	65	193	105
East Bodden Town	George Town Hospital	41	38	44	47	47	45	64	52	56	49	108	86
	Camana Bay	41	37	44	42	48	45	68	53	60	54	110	87
	Walkers Road Schools	35	32	46	45	50	46	68	59	59	55	118	98
	Owen Roberts Airport	39	36	44	42	46	42	63	46	56	49	99	80
Average Travel Time		**49**	**44**	**58**	**52**	**61**	**54**	**86**	**60**	**73**	**61**	**178**	**105**
% Change from No-Build		-	**-9%**	-	**-11%**	-	**-11%**	-	**-31%**	-	**-17%**	-	**-41%**

Table note: These travel times were calculated as a combined single average, including both AM peak hour westbound travel times and PM peak hour eastbound travel times. Travel times are calculated from North Side/East End based on the average travel times across the entire district to each key destination. Travel times are calculated from East Bodden Town based on a selection of zones located near Lookout Road.

Compared to Future No-Build conditions, the Proposed Project is anticipated to provide travel time benefits to North Side, East End, and eastern Bodden Town residents traveling to key destinations in George Town, ranging from 9% to 41% average benefit depending on the analysis year (**Table 7-7**). By providing an additional higher-capacity roadway, the Proposed Project is expected to improve travel times particularly within the study area. The Proposed Project may also provide more significant travel time savings to North Side residents compared to Bodden Town and East End residents because Bodden Town and East End drivers may still favour the existing coastal road as a more direct route.

Due to differing employment and population growth assumptions, the 2074 Low Growth conditions are generally anticipated to experience higher travel times than the 2074 Medium Growth conditions. As discussed in **Section 7.3.5.1: 2074 Land Use Scenarios**, Medium Growth conditions assume employment centres will be developed within Bodden Town, North Side, and East End, allowing eastern district residents to seek shorter commutes to these local job opportunities. The Medium Growth scenario also assumes lower overall population growth within Bodden Town and East End than the Low Growth conditions. Therefore, the Medium Growth scenario is generally expected to result in shorter travel times compared to the Low Growth scenario due to improved employment opportunities assumed within eastern districts as well as a lower total population assumed in these areas, likely reducing the number of long-distance east-west commutes. Ultimately, the Proposed Project continues to improve travel times for both the Low Growth and Medium Growth conditions when compared to Future No-Build conditions.

7.4.5.3 Tourist Travel Times

As a tourist destination, Grand Cayman faces the distinct challenge of accommodating cruise passengers with unique travel patterns. Cruise passengers typically arrive to the George Town Cruise Terminal in the morning and travel to various tourist destinations across the island, so their travel patterns have opposite directionality than the typical commuters living in Bodden Town, North Side, and East End. To evaluate tourist travel, this section considers travel times to North Side tourist destinations including Rum Point, Queen Elizabeth II Botanical Gardens, and the Mastic Trail, as well as Bodden Town tourist destinations such as Bodden Town Mission House and Meagre Bay Pond. **Table 7-8** provides travel times between the cruise port and these tourist destinations to show how the Proposed Project is expected to improve tourist travel times when compared to Future No-Build conditions.

Table 7-8: Tourist Travel Times to/from Cruise Port, AM/PM Average Travel Time (minutes)

Origin	Destination	2026		2036		2046		2074 Low		2074 Medium		2074 High	
		No-Build	Proposed Project	No-Build	Proposed Project	No-Build	Proposed Project	No-Build	Proposed Project	No-Build	Proposed Project	No-Build	Proposed Project
Cruise Port	Rum Point / Starfish Point	51	46	63	48	63	53	92	57	90	75	164	77
Cruise Port	Bodden Town Mission House	24	23	25	24	29	28	36	32	48	42	73	58
Cruise Port	Botanical Gardens	35	30	50	32	47	36	79	45	67	50	144	75
Cruise Port	Mastic Trail	36	29	50	31	50	36	79	40	75	59	157	73
Cruise Port	Meagre Bay Pond	27	24	29	27	33	31	45	34	52	45	89	54
Average Travel Time Cruise Port / Destination		**34**	**30**	**43**	**33**	**44**	**37**	**66**	**42**	**67**	**54**	**125**	**67**
% Change from No-Build		-	**-11%**	-	**-25%**	-	**-18%**	-	**-37%**	-	**-19%**	-	**-46%**

The Proposed Project is anticipated to provide significant travel time benefits to these tourist destinations in Bodden Town and North Side, ranging from 11% to 25% average benefit compared to Future No-Build conditions. By providing an additional higher-capacity roadway, the Proposed Project is expected to improve travel times particularly within the study area. The Proposed Project may also provide more significant travel time improvements to North Side destinations like Rum Point, the Botanical Gardens, and the Mastic Trail compared to Bodden Town destinations like the Mission House and Meagre Bay Pond because Bodden Town drivers may still favour the existing coastal road as a more direct route.

Due to differing employment and population growth assumptions, the 2074 Low Growth conditions are generally anticipated to experience higher travel times than the 2074 Medium Growth conditions. As discussed in **Section 7.3.5.1: 2074 Land Use Scenarios**, Medium Growth conditions assume employment centres will be developed within Bodden Town, North Side, and East End, allowing eastern district residents to seek shorter commutes to these local job opportunities. The Medium Growth scenario also assumes lower overall population growth within Bodden Town and East End than the Low Growth conditions. As a result, the Medium Growth scenario is generally expected to experience in shorter travel times compared to the Low Growth scenario due to improved employment opportunities assumed within eastern districts as well as a lower total population assumed in these areas, likely reducing the number of long-distance east-west commutes. Ultimately, the Proposed Project continues to improve travel times for both the Low Growth and Medium Growth conditions when compared to Future No-Build conditions.

7.4.6 Intersection Delay

As described in **Section 7.2.2.5: Traffic Analysis Model,** PTV VISTRO 2022 was utilised to analyse intersection delay during the 6:00 to 7:00 AM and 5:00 to 6:00 PM peak hours, and detailed results can be found in **Appendix G.1: VISTRO Reports**. The 13 existing intersections included in the analysis are listed below and shown in **Figure 7-28**:

- 100: EWA at Hirst Road
- 200: Shamrock Road at Hirst Road
- 300: Shamrock Road at Woodland Drive
- 400: Shamrock Road at Agricola Drive
- 500: Shamrock Road at Brightview Drive / Calla Lily Drive
- 600: Shamrock Road at Beach Bay Road
- 700: Shamrock Road at Northward Road
- 800: Shamrock Road at Condor Road
- 900: Bodden Town Road at Bodden Town Bypass
- 1000: Bodden Town Road at Long Fellow Drive
- 1100: Bodden Town Road at Frank Sound Road
- 1200: Frank Sound Road at Clifton Hunter High School
- 1300: Frank Sound Road at North Side Road / Old Robin Road

Figure 7-28: Traffic Analysis Intersections and Turnaround Points

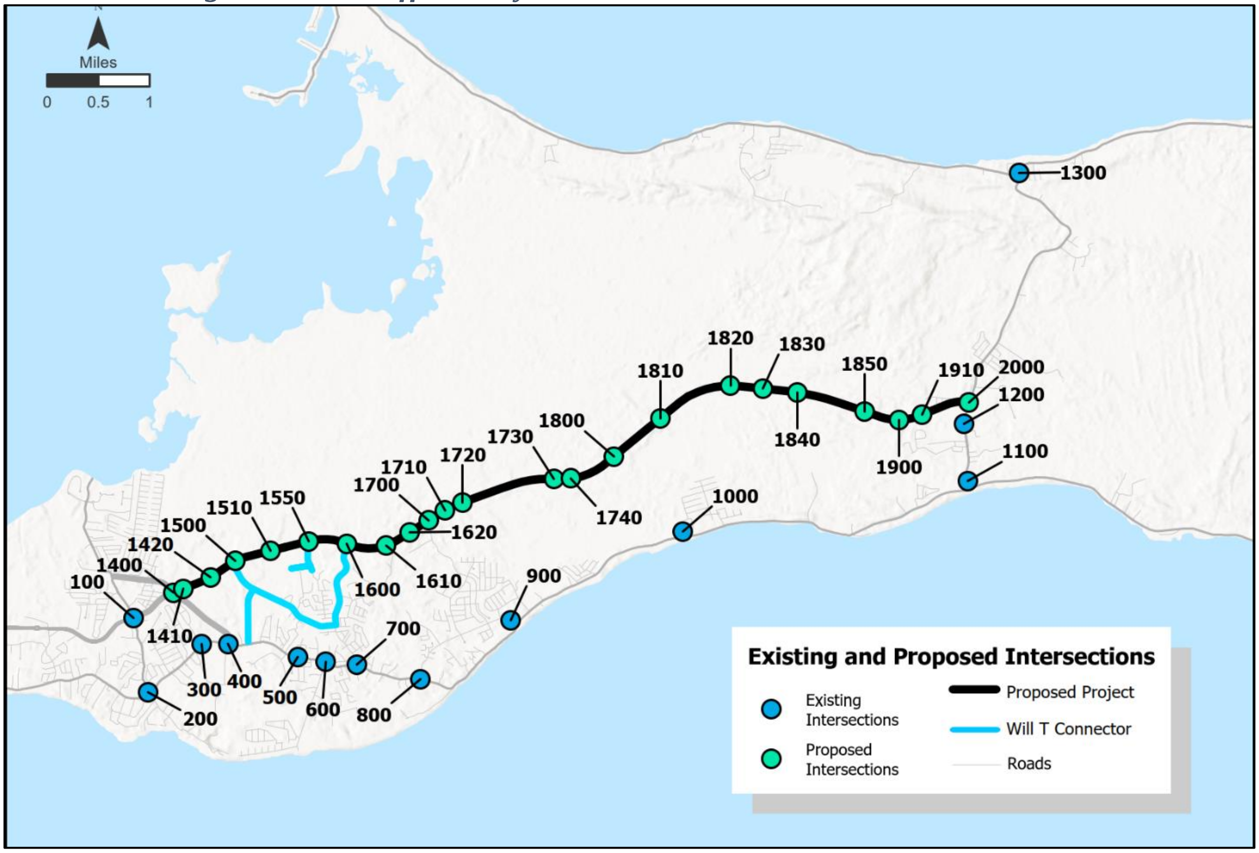


Figure 7-28 also shows the Proposed Project, as well as the following Proposed Project intersections and turnaround points:

- 1400: EWA at Agricola Drive Connector
- 1410: EWA at North Access Point #1 (east of Agricola Drive Connector)
- 1420: EWA at South Access Point #1 (east of Agricola Drive Connector)
- 1500: EWA at Will T Connector #1 / North Access Point #2
- 1510: EWA at U-Turn #1 (between Will T Connector #1 and #2)
- 1550: EWA at Will T Connector #2
- 1600: EWA at Northward Road (Will T Connector #3)
- 1610: EWA at South Access Point #2 (east of Northward Road)
- 1620: EWA at U-Turn #2 (west of Lookout Road)
- 1700: EWA at Lookout Road / North Access Point #3
- 1710: EWA at U-Turn #3 (east of Lookout Road)
- 1720: EWA at South Access Point #3 (east of Lookout Road)
- 1730: EWA at North Access Point #4 (near Meagre Bay Pond)
- 1740: EWA at U-Turn #4 (near Meagre Bay Pond)
- 1800: EWA at Long Fellow Drive (near Meagre Bay Pond)
- 1810: EWA at U-Turn #5 (near Meagre Bay Pond)
- 1820: EWA at North Access Point #5 (near Bodden Town District Line)

- 1830: EWA at South Access Point #4 (near Bodden Town District Line)
- 1840: EWA at U-Turn #6 (near Bodden Town District Line)
- 1850: EWA at North Access Point #6 (near Mastic Trail)
- 1900: EWA at Stepping Stone Drive (near Mastic Trail)
- 1910: EWA at North Access Point #7 (east of Mastic Trail)
- 2000: Frank Sound Road at EWA

Using HCM methodologies, VISTRO reports intersection delay, which is the amount of time each vehicle will be slowed when moving through an intersection. Delay is first calculated at the individual movement level (left-turn, through, right-turn) for each vehicle, then at approach level (eastbound, westbound, northbound, southbound) for all vehicles on that approach, and then at the overall intersection level. Delay, measured in seconds, is then translated into a letter grade known as level of service (LOS). LOS ranges from “A” which indicates minimal delay, to “F” which indicates failing characteristics such as high delay, systemic breakdowns, long queues, or slow travel. LOS results were compiled for the Baseline Conditions, Future No-Build, and Proposed Project by intersection (**Appendix G.2: VISTRO LOS Summary Tables**).

In some locations, the roadway geometry could not accurately be modelled as a single intersection; for example, Shamrock Road at Hirst Road features a total of three intersections, which accounts for the fact that Shamrock Road splits into two one-way streets, which each intersect with Hirst Road individually. Furthermore, that intersection also features a jug-handle configuration (which eliminates right-turns at the main intersection by redirecting vehicles to a separate intersection where they can make a U-turn before returning to the main intersection to perform a left-turn), again due to the bifurcation of Shamrock Road. Therefore, there may be additional points on the summary maps, whereas in the summary tables, these individual intersections were combined to reflect how the overall intersection performs.

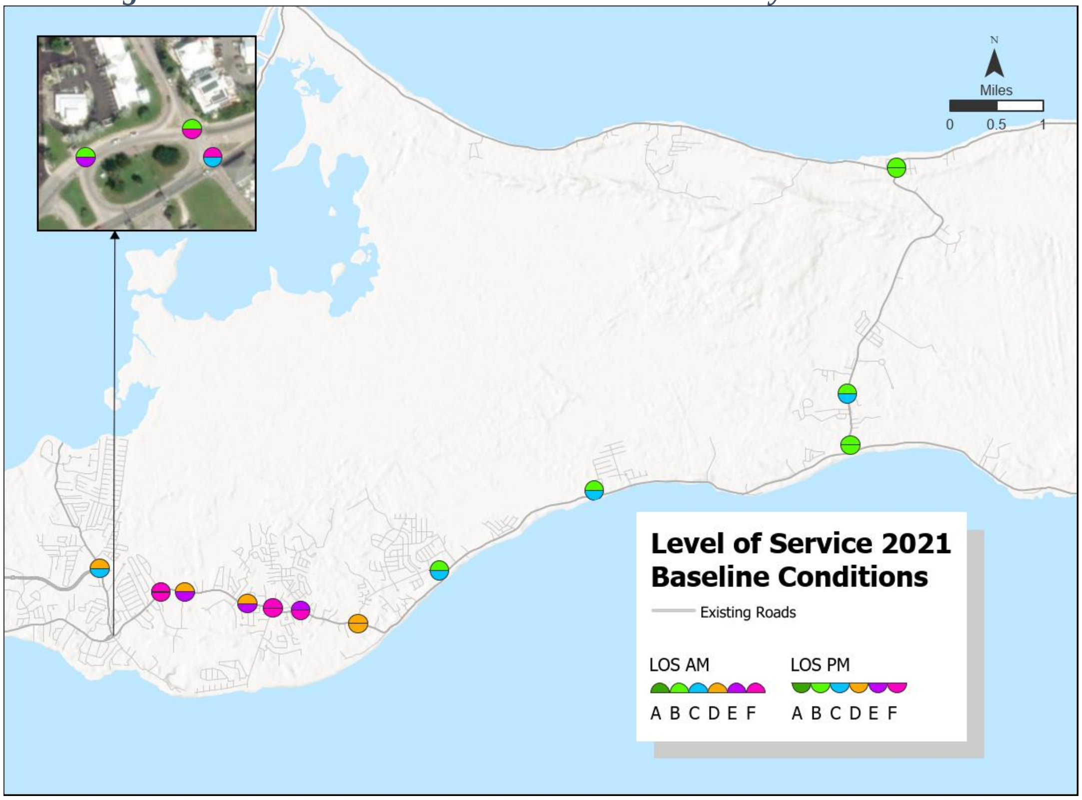
For the Future No-Build and Proposed Project, volumes generated by VISUM were compiled at the intersection TMC level (**Appendix G.1: VISTRO Reports**) and provided as Average Daily Traffic (ADT) link volumes (**Appendix G.3: Average Daily Traffic Volume Diagrams**). The ADT volumes provided in Appendix G.3 were developed for informational purposes by applying a uniform K-factor to peak hour volumes based on traffic counts taken across the study area. During detailed design of the Proposed Project beyond this EIA, additional forecasting will be required to develop design-specific ADT volumes.

7.4.6.1 Baseline Year 2021

Baseline Conditions

Traffic volumes for the 2021 Baseline Conditions were input into the existing roadway network. **Figure 7-29** and **Table 7-9** below show the results of the 6:00 to 7:00 AM and 5:00 to 6:00 PM peak hours for the Baseline Conditions intersection delay.

Figure 7-29: Baseline Conditions Intersection Delay AM / PM Peak



In the 2021 Baseline Conditions:

- Seven intersections perform at LOS D or better in both peak hours.
- Two intersections perform at LOS D or better in one peak hour, but at LOS E/F in the other peak hour.
- Four intersections perform at LOS E/F in both peak hours.

Table 7-9: Baseline Conditions Intersection Delay Summary Table Existing Intersections

#	Intersection	Level of Service (AM / PM)
		2021 Baseline
100	**EWA at Hirst Rd**	D / C
200	**Shamrock Rd at Hirst Rd**	**F** / **F**
300	**Shamrock Rd at Woodland Dr**	**F** / **F**
400	**Shamrock Rd at Agricola Dr**	D / **E**
500	**Shamrock Rd at Brightview Dr / Calla Lily Dr**	D / **E**
600	**Shamrock Rd at Beach Bay Rd**	**F** / **F**
700	**Shamrock Rd at Northward Rd**	**E** / **F**
800	**Shamrock Rd at Condor Rd**	D / D
900	**Bodden Town Rd at Bodden Town Bypass**	B / C
1000	**Bodden Town Rd at Long Fellow Dr**	B / C
1100	**Bodden Town Rd at Frank Sound Rd**	B / C
1200	**Frank Sound Rd at Clifton Hunter HS**	B / C
1300	**Frank Sound Rd at North Side Rd / Old Robin Rd**	B / B

Table Note: Refer to **Figure 7-28** for map of intersection locations.

7.4.6.2 Future Year 2026

Future No-Build Conditions

The 2026 future year traffic volumes were input into the Future No-Build roadway network as a basis for comparison to the Proposed Project. Changes to the Future No-Build network included the conversion of the intersection of EWA at Hirst Road to a roundabout, as well as the addition of a new intersection at EWA and Agricola Drive Connector. **Figure 7-30** and **Table 7-10** below show the 2026 Future No-Build conditions performance results for the AM and PM peak hour.

Proposed Project

The 2026 future year traffic volumes generated by VISUM for the Proposed Project were compiled at the intersection TMC level (**Appendix G.1: VISTRO Reports**). Traffic volumes for the 2026 Proposed Project were input into the proposed roadway network, which includes the new EWA Extension as a two-lane divided roadway, roundabout intersections at either end of the corridor, and left-in/left-out driveways with U-turns along the corridor itself. **Figure 7-31**, **Table 7-10**, and **Table 7-11** show the results of the AM and PM peak hour for the 2026 Proposed Project intersection delay.

The 2026 Proposed Project is expected to improve intersection delay. No failing intersection delay are expected at any location in the network. The new roadway is expected to redirect a large portion of the volume away from the existing coastal roadway, reducing intersection delays. Additionally, the intersections on the new roadway will be designed to meet performance acceptability.

Figure 7-30: 2026 Future No-Build Intersection Delay AM / PM Peak

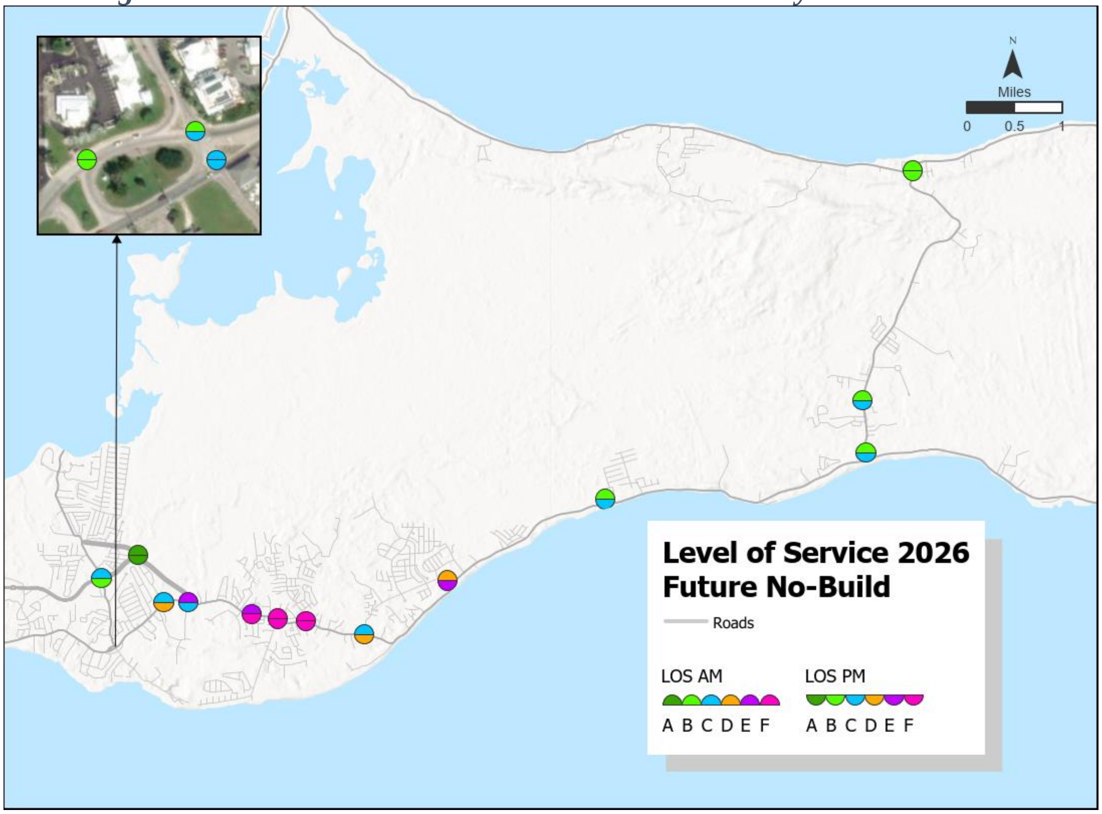


Figure 7-31: 2026 Proposed Project Intersection Delay AM / PM Peak

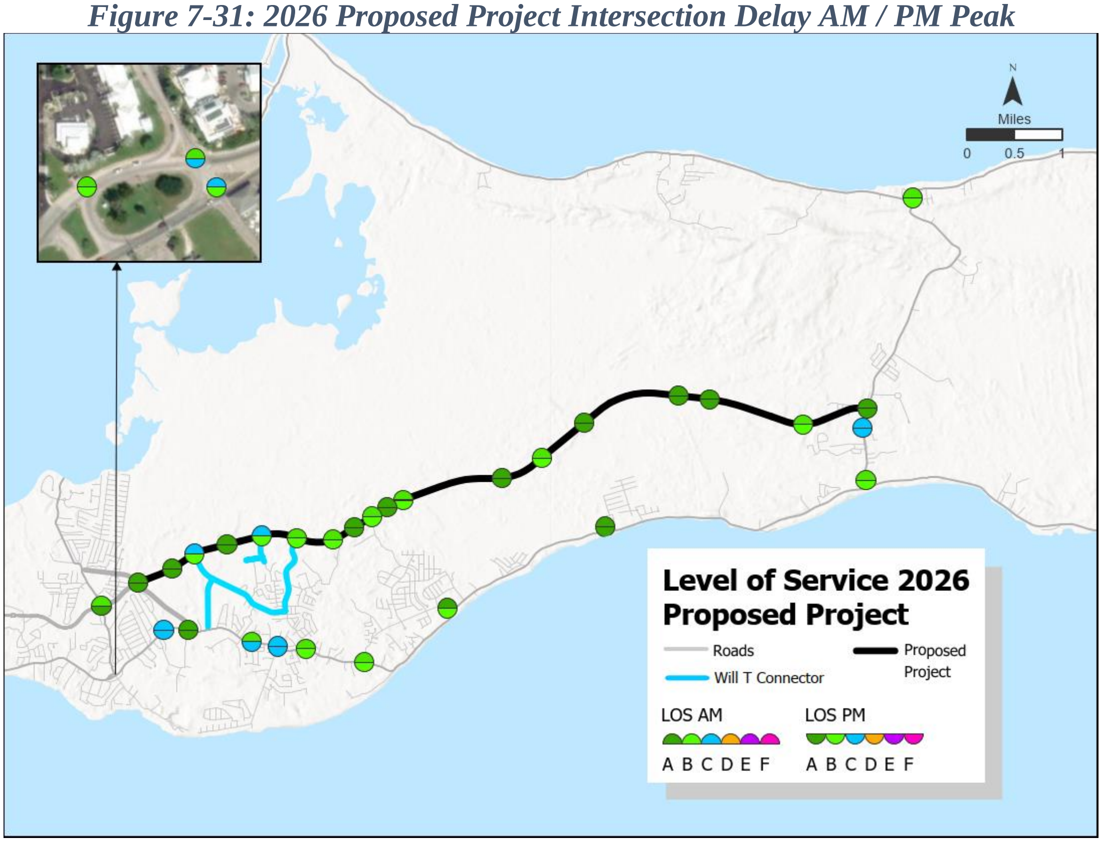


Table 7-10: 2026 Intersection Delay Summary Table, Existing Intersections

#	Intersection	Level of Service (AM / PM)	
		2026 Future No-Build	2026 Proposed Project
100	EWA at Hirst Rd	C / B	B / A
200	Shamrock Rd at Hirst Rd	C / C	C / C
300	Shamrock Rd at Woodland Ave	C / D	C / C
400	Shamrock Rd at Agricola Dr	E / C	A / A
500	Shamrock Rd at Brightview Dr / Calla Lily Dr	E / F	B / C
600	Shamrock Rd at Beach Bay Rd	F / F	C / C
700	Shamrock Rd at Northward Rd	F / F	B / B
800	Shamrock Rd at Condor Rd	C / D	B / B
900	Bodden Town Rd at Bodden Town Bypass	D / E	A / B
1000	Bodden Town Rd at Long Fellow Dr	B / C	A / A
1100	Bodden Town Rd at Frank Sound Rd	B / C	B / B
1200	Frank Sound Rd at Clifton Hunter HS	B / C	C / C
1300	Frank Sound Rd at North Side Rd / Old Robin Rd	B / B	B / B

Table Note: Refer to **Figure 7-28** for map of intersection locations.

Table 7-11: 2026 Intersection Delay Summary Table, Proposed Intersections

#	Intersection	Level of Service (AM / PM)	
		2026 Future No-Build	2026 Proposed Project
1400	EWA at Agricola Dr Connector	A / A	A / A
1420	EWA at South Access Point #1 (east of Agricola Dr Connector)	-	A / A
1500	EWA at Will T Connector #1 / North Access Point #2	-	C / B
1510	EWA at U-Turn #1 (between Will T Connector #1 and #2)	-	A / A
1550	EWA at Will T Connector #2	-	C / B
1600	EWA at Northward Rd (Will T Connector #3)	-	B / B
1610	EWA at South Access Point #2 (east of Northward Rd)	-	B / B
1620	EWA at U-Turn #2 (west of Lookout Rd)	-	A / A
1700	EWA at Lookout Rd / North Access Point #3	-	B / B
1710	EWA at U-Turn #3 (east of Lookout Rd)	-	A / A
1720	EWA at South Access Point #3 (east of Lookout Rd)	-	B / B
1740	EWA at U-Turn #4 (near Meagre Bay Pond)	-	A / A
1800	EWA at Long Fellow Dr (near Meagre Bay Pond)	-	B / B
1810	EWA at U-Turn #5 (near Meagre Bay Pond)	-	A / A
1830	EWA at South Access Point #4 (near Bodden Town District Line)	-	A / A
1840	EWA at U-Turn #6 (near Bodden Town District Line)	-	A / A
1900	EWA at Stepping Stone Dr (near Mastic Trail)	-	B / B
2000	Frank Sound Rd at EWA	-	A / A

Table Note: Refer to **Figure 7-28** for map of intersection locations.

7.4.6.3 Future Year 2036

Future No-Build Conditions

The 2036 future year traffic volumes were input into the Future No-Build roadway network as a basis for comparison to the Proposed Project. Within the study area, the 2036 Future No-Build roadway network is the same as that of the 2026 Future No-Build. **Figure 7-32** and **Table 7-12** below show the results of the AM and PM peak hour for the 2036 Future No-Build conditions intersection delay.

Proposed Project

The 2036 future year volumes generated by VISUM for the Proposed Project were compiled at the intersection TMC level (**Appendix G.1: VISTRO Reports**). Traffic volumes for the 2036 Proposed Project were input into the proposed roadway network, which includes converting Frank Sound Road at Clifton Hunter High School to a traffic signal, adding access points to the northern side of EWA Extension, and including transit lanes along the southern side of EWA Extension. As a result of the transit lanes positioned south of the corridor, all access points to the southern side of EWA Extension will be signalized to safely accommodate bus traffic. **Figure 7-33**, **Table 7-12**, and **Table 7-13** show the results of the AM and PM peak hour for the 2036 Proposed Project intersection delay.

The 2036 Proposed Project is expected to reduce intersection delays. The only failing intersection delay expected on the network are on the unimproved Shamrock Road, stemming from minor side street movements at stop-controlled intersections; however, even with similar LOS letter grades, the Proposed Project network experiences less delay than the Future No-Build. The new roadway is expected to redirect a large portion of the volume away from the existing coastal roadway, reducing intersection delays.

Figure 7-32: 2036 Future No-Build Intersection Delay AM / PM Peak

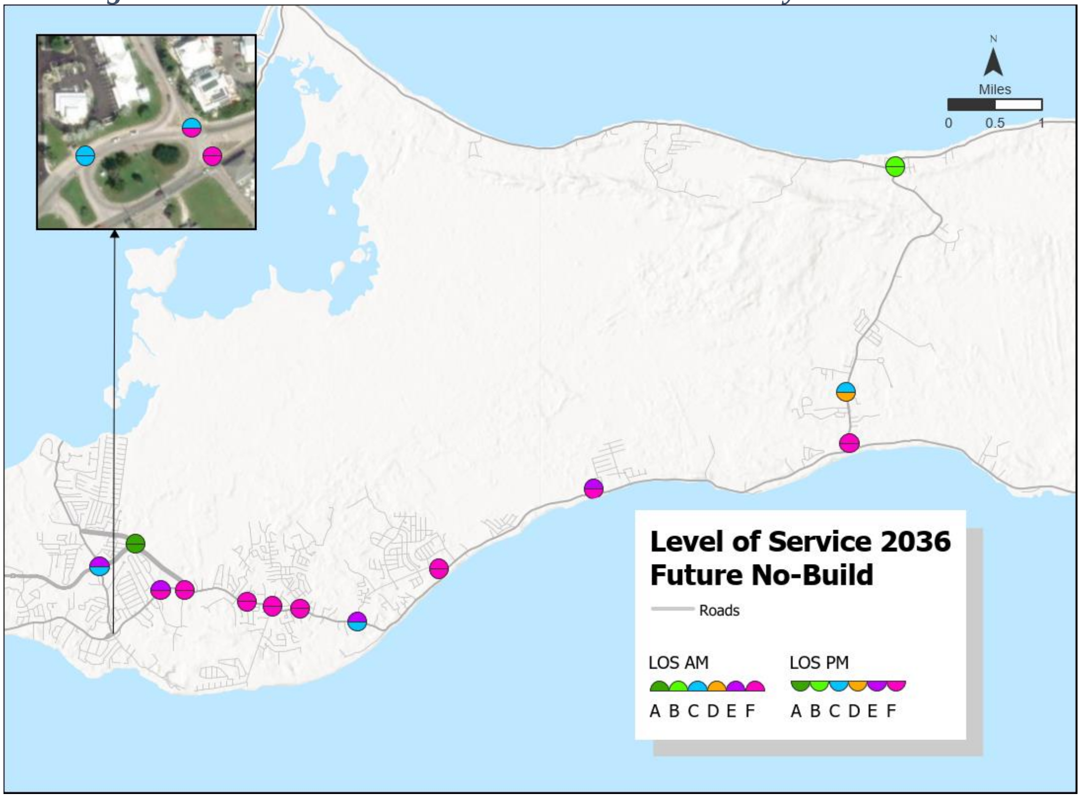


Figure 7-33: 2036 Proposed Project Intersection Delay AM / PM Peak

Table 7-12: 2036 Intersection Delay Summary Table Existing Intersections

#	Intersection	Level of Service (AM / PM)	
		2036 Future No-Build	2036 Proposed Project
100	EWA at Hirst Rd	E / C	C / B
200	Shamrock Rd at Hirst Rd	F / F	F / E
300	Shamrock Rd at Woodland Dr	E / F	C / C
400	Shamrock Rd at Agricola Dr	F / F	A / A
500	Shamrock Rd at Brightview Dr / Calla Lily Dr	F / F	D / C
600	Shamrock Rd at Beach Bay Rd	F / F	E / E
700	Shamrock Rd at Northward Rd	F / F	C / C
800	Shamrock Rd at Condor Rd	E / C	C / C
900	Bodden Town Rd at Bodden Town Bypass	F / F	C / C
1000	Bodden Town Rd at Long Fellow Dr	E / F	B / B
1100	Bodden Town Rd at Frank Sound Rd	F / F	C / D
1200	Frank Sound Rd at Clifton Hunter HS	C / D	C[1] / C[1]
1300	Frank Sound Rd at North Side Rd / Old Robin Rd	B / B	B / B

Table Note: Refer to **Figure 7-28** for map of intersection locations.

[1]LOS results shown are with mitigation improvements as discussed in **Section 7.5: Mitigation Measures**. Without mitigation, LOS results are worse than the Future No-Build.

Table 7-13: 2036 Intersection Delay Summary Table Proposed Intersections

#	Intersection	Level of Service (AM / PM) 2036 Future No-Build	Level of Service (AM / PM) 2036 Proposed Project
1400	EWA at Agricola Dr Connector	A / A	B / B
1410	EWA at North Access Point #1 (east of Agricola Dr Connector)	-	A / A
1420	EWA at South Access Point #1 (east of Agricola Dr Connector)	-	A / A
1500	EWA at Will T Connector #1 / North Access Point #2	-	B / A
1510	EWA at U-Turn #1 (between Will T Connector #1 and #2)	-	A / A
1550	EWA at Will T Connector #2	-	B / A
1600	EWA at Northward Rd (Will T Connector #3)	-	B / A
1610	EWA at South Access Point #2 (east of Northward Rd)	-	A / A
1620	EWA at U-Turn #2 (west of Lookout Rd)	-	A / A
1700	EWA at Lookout Rd / North Access Point #3	-	B / B
1710	EWA at U-Turn #3 (east of Lookout Rd)	-	A / A
1720	EWA at South Access Point #3 (east of Lookout Rd)	-	B / A
1730	EWA at North Access Point #4 (near Meagre Bay Pond)	-	A / A
1740	EWA at U-Turn #4 (near Meagre Bay Pond)	-	A / A
1800	EWA at Long Fellow Dr (near Meagre Bay Pond)	-	A / A
1810	EWA at U-Turn #5 (near Meagre Bay Pond)	-	A / A
1820	EWA at North Access Point #5 (near Bodden Town District Line)	-	A / A
1830	EWA at South Access Point #4 (near Bodden Town District Line)	-	A / A
1840	EWA at U-Turn #6 (near Bodden Town District Line)	-	A / A
1850	EWA at North Access Point #6 (near Mastic Trail)	-	A / A
1900	EWA at Stepping Stone Dr (near Mastic Trail)	-	A / A
1910	EWA at North Access Point #7 (east of Mastic Trail)	-	B / B
2000	Frank Sound Rd at EWA	-	A / A

Table Note: Refer to **Figure 7-28** for map of intersection locations.

7.4.6.4 Future Year 2046

Future No-Build Conditions

The 2046 future year traffic volumes were input into the Future No-Build roadway network as a future year basis for comparison to the Proposed Project. The 2046 Future No-Build roadway network is the same as that of the 2036 Future No-Build within the immediate study area. **Figure 7-34** and **Table 7-14** below show the results of the AM and PM peak hour for the 2046 Future No-Build conditions intersection delay.

Proposed Project

The 2046 future year volumes generated by VISUM for the Proposed Project were compiled at the intersection TMC level (**Appendix G.1: VISTRO Reports**). Traffic volumes for the 2046 Proposed Project were input into the proposed roadway network, which includes widening Section 2 of the EWA Extension (Woodland Drive/Agricola Drive Connector to Lookout Road) to four lanes, restriping the southbound approach of Frank Sound Road to Clifton Hunter High School to include a right-turn lane, and converting EWA at Agricola Drive Connector to a three-lane roundabout with bypass lanes. **Figure 7-35**, **Table 7-14**, and **Table 7-15** show the results of the AM and PM peak hour for the 2046 Proposed Project intersection delay.

The 2046 Proposed Project is expected to reduce intersection delay. The only failing intersection delay expected on the network are along the unimproved Shamrock Road and Frank Sound Road, stemming from minor side street movements. However, even with similar LOS letter grades, the Proposed Project network experiences less delay than the Future No-Build. The new roadway is expected to redirect a large portion of the volume away from the existing coastal roadway, reducing intersection delays.

Figure 7-34: 2046 Future No-Build Intersection Delay AM / PM Peak

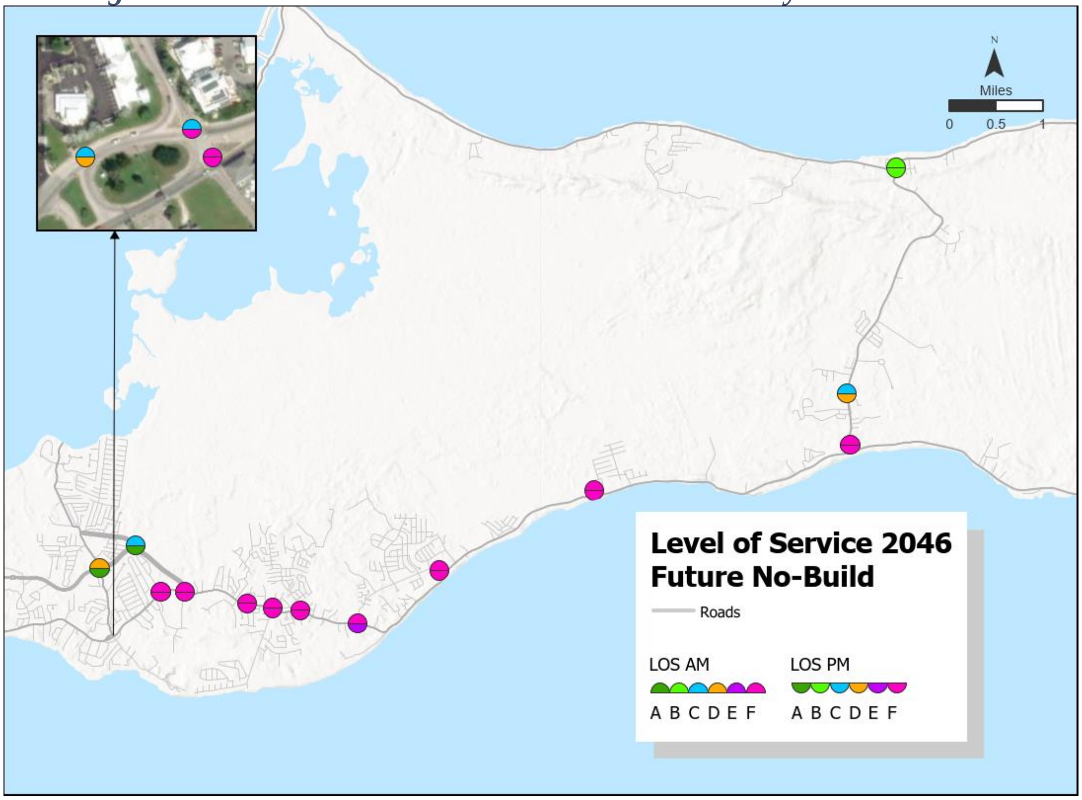


Figure 7-35: 2046 Proposed Project Intersection Delay AM / PM Peak

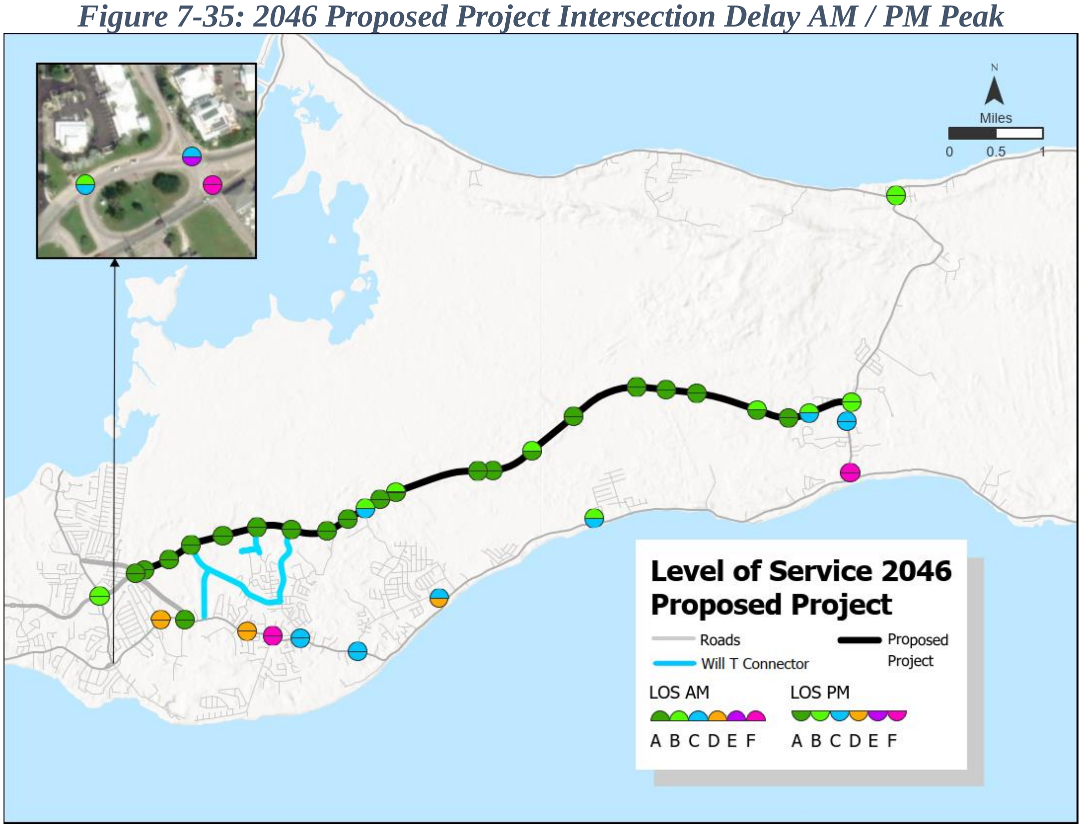


Table 7-14: 2046 Intersection Delay Summary Table Existing Intersections

#	Intersection	Level of Service (AM / PM)	
		2046 Future No-Build	2046 Proposed Project
100	EWA at Hirst Rd	D / A	B / B
200	Shamrock Rd at Hirst Rd	F / F	F / F
300	Shamrock Rd at Woodland Dr	F / F	D / D
400	Shamrock Rd at Agricola Dr	F / F	A / A
500	Shamrock Rd at Brightview Dr / Calla Lily Dr	F / F	D / D
600	Shamrock Rd at Beach Bay Rd	F / F	F / F
700	Shamrock Rd at Northward Rd	F / F	C / C
800	Shamrock Rd at Condor Rd	F / E	C / C
900	Bodden Town Rd at Bodden Town Bypass	F / F	C / D
1000	Bodden Town Rd at Long Fellow Dr	F / F	B / C
1100	Bodden Town Rd at Frank Sound Rd	F / F	F / F
1200	Frank Sound Rd at Clifton Hunter HS	C / D	C[1] / C[1]
1300	Frank Sound Rd at North Side Rd / Old Robin Rd	B / B	B / B

Table Note: Refer to **Figure 7-28** for map of intersection locations.

[1]LOS results shown are with mitigation improvements as discussed in **Section 7.5: Mitigation Measures**. Without mitigation, LOS results are worse than the Future No-Build.

Table 7-15: 2046 Intersection Delay Summary Table Proposed Intersections

#	Intersection	Level of Service (AM / PM)	
		2046 Future No-Build	2046 Proposed Project
1400	EWA at Agricola Dr Connector	C / A	A[1] / A[1]
1410	EWA at North Access Point #1 (east of Agricola Dr Connector)	-	A / A
1420	EWA at South Access Point #1 (east of Agricola Dr Connector)	-	A / A
1500	EWA at Will T Connector #1 / North Access Point #2	-	A / A
1510	EWA at U-Turn #1 (between Will T Connector #1 and #2)	-	A / A
1550	EWA at Will T Connector #2	-	A / A
1600	EWA at Northward Rd (Will T Connector #3)	-	A / A
1610	EWA at South Access Point #2 east of Northward Rd)	-	A / A
1620	EWA at U-Turn #2 (west of Lookout Rd)	-	A / A
1700	EWA at Lookout Rd / North Access Point #3	-	B / C
1710	EWA at U-Turn #3 (east of Lookout Rd)	-	A / A
1720	EWA at South Access Point #3 (east of Lookout Rd)	-	B / A
1730	EWA at North Access Point #4 (near Meagre Bay Pond)	-	A / A
1740	EWA at U-Turn #4 (near Meagre Bay Pond)	-	A / A
1800	EWA at Long Fellow Dr (near Meagre Bay Pond)	-	B / A
1810	EWA at U-Turn #5 (near Meagre Bay Pond)	-	A / A
1820	EWA at North Access Point #5 (near Bodden Town District Line)	-	A / A
1830	EWA at South Access Point #4 (near Bodden Town District Line)	-	A / A
1840	EWA at U-Turn #6 (near Bodden Town District Line)	-	A / A
1850	EWA at North Access Point #6 (near Mastic Trail)	-	B / A
1900	EWA at Stepping Stone Dr (near Mastic Trail)	-	A / A
1910	EWA at North Access Point #7 (east of Mastic Trail)	-	B / C
2000	Frank Sound Rd at EWA	-	B / B

Table Note: Refer to **Figure 7-28** for map of intersection locations.

[1]LOS results shown are with mitigation improvements as discussed in **Section 7.5: Mitigation Measures**. Without mitigation, LOS results are worse than the Future No-Build.

7.4.6.5 Future Year 2074

Future No-Build Conditions

The 2074 future year traffic volumes were input into the Future No-Build roadway network as a future year basis for comparison to the Proposed Project. Traffic volumes were input for three different land use scenarios: Low Growth, Medium Growth, and High Growth. These land use scenarios each assume different future growth patterns and traffic volumes, but each scenario was evaluated using the same 2074 Future No-Build roadway network. The 2074 Future No-Build roadway network is the same as that of the 2046 Future No-Build. **Figure 7-36**, **Figure 7-38**, **Figure 7-40**, **Table 7-16**, and **Table 7-17** below show the results of the AM and PM peak hour for the 2074 Future No-Build conditions intersection delay.

Proposed Project (Low Growth)

The 2074 Low Growth volumes generated by VISUM for the Proposed Project were compiled at the intersection TMC level (**Appendix G.1: VISTRO Reports**). Traffic volumes for the 2074 Proposed Project were input into the proposed roadway network, which is the same as that of the 2074 Proposed Project (Medium Growth). **Figure 7-37**, **Table 7-16**, and **Table 7-17** show the results of the AM and PM peak hour for the 2074 Proposed Project (Low Growth) intersection delay.

Proposed Project (Medium Growth)

The 2074 Medium Growth volumes generated by VISUM for the Proposed Project were compiled at the intersection TMC level **(Appendix G.1: VISTRO Reports**). Traffic volumes for the 2074 Proposed Project (Medium Growth) were input into the proposed roadway network, which includes widening Section 3 of the EWA Extension (Lookout Road to Frank Sound Road) to four lanes and converting Bodden Town Road at Frank Sound Road to a traffic signal. **Figure 7-39**, **Table 7-16**, and **Table 7-17** show the results of the AM and PM peak hour for the 2074 Proposed Project (Medium Growth) intersection delay.

Proposed Project (High Growth)

The 2074 High Growth volumes generated by VISUM for the Proposed Project were compiled at the intersection TMC level (**Appendix G.1: VISTRO Reports**). Traffic volumes for the 2074 Proposed Project (High Growth) were input into the proposed roadway network, which is the same as that of the 2074 Proposed Project (Medium Growth). **Figure 7-41**, **Table 7-16**, and **Table 7-17** show the results of the AM and PM peak hour for the 2074 Proposed Project (High Growth) intersection delay.

Under the 2074 Low Growth and Medium Growth conditions, the Proposed Project is expected to reduce intersection delay. The only location where the Proposed Project exhibits worse intersection delay relative to the Future No-Build is at Woodland Drive and Shamrock Road in the Low Growth scenario because most east/west travellers in the Future No-Build are expected to detour to the EWA Extension using the Agricola Drive Connector, which results in lower volumes at the Woodland Drive intersection. The Proposed Project (Low Growth) is expected to improve conditions on the coastal road east of Agricola Drive, so more vehicles are expected to continue westbound along Shamrock Road through the Woodland Drive intersection, resulting in a worse LOS. For both Low Growth and Medium Growth conditions, other failing intersection delay expected on the network are on the unimproved Shamrock Road, stemming from minor side street movements. Intersections along the Proposed Project are expected to operate well with minimal delay under both Low and Medium Growth conditions due to widening EWA Section 3 (Lookout Road to Frank Sound Road) to four lanes and converting Bodden Town Road at Frank Sound Road to a traffic signal.

The 2074 Proposed Project (High Growth) is anticipated to exhibit poor intersection delay in both the Future No-Build and Proposed Project as the anticipated volume growth exceeds the capacity across the entire roadway network.

Figure 7-36: 2074 Future No-Build (Low Growth) Intersection Delay AM / PM Peak

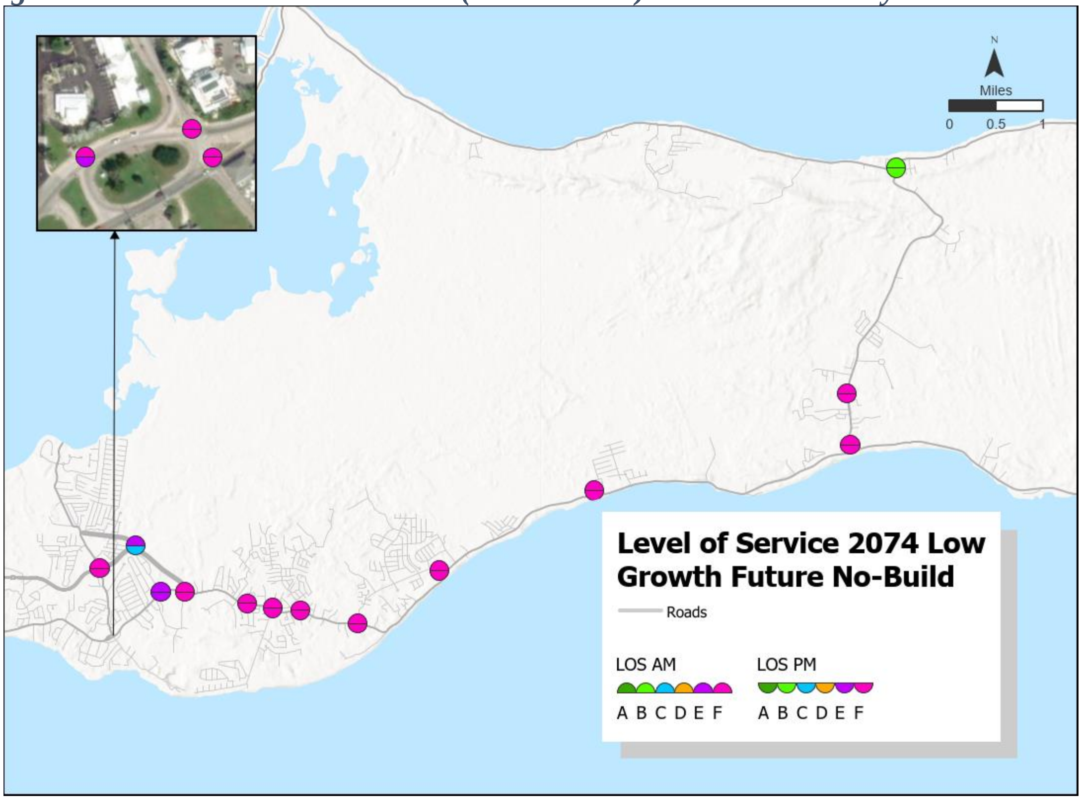


Figure 7-37: 2074 Proposed Project (Low Growth) Intersection Delay AM / PM Peak

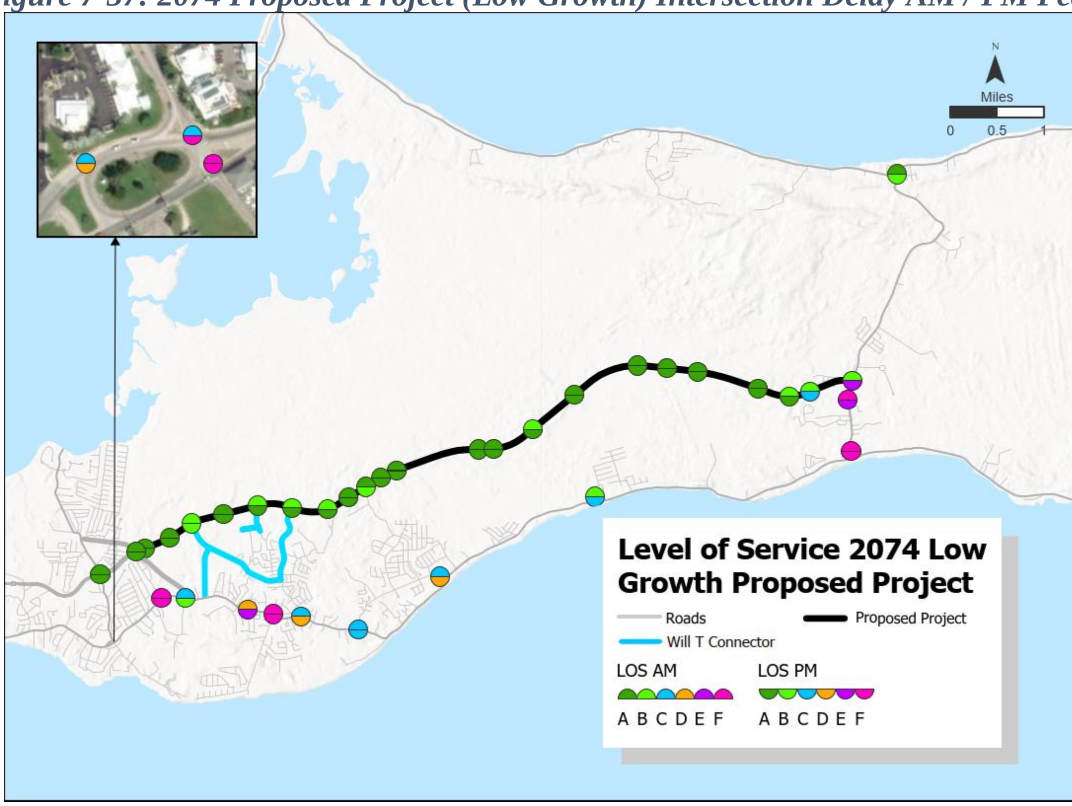


Figure 7-38: 2074 Future No-Build (Medium Growth) Intersection Delay AM / PM Peak

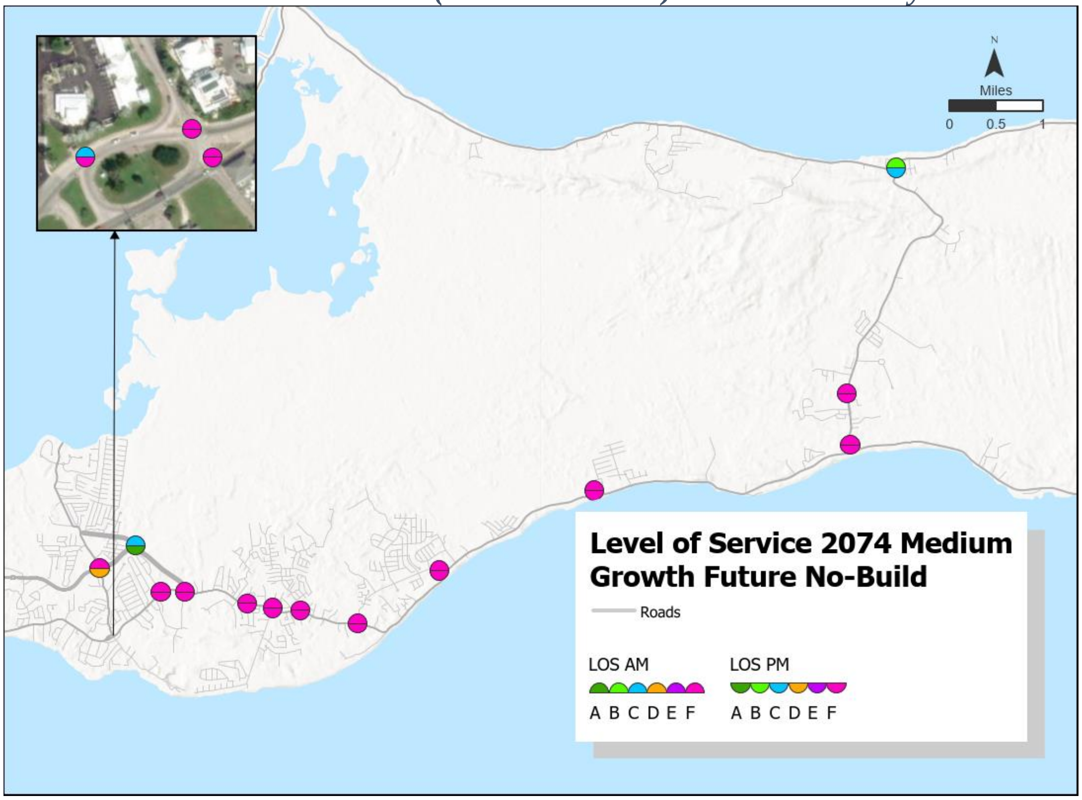


Figure 7-39: 2074 Proposed Project (Medium Growth) Intersection Delay AM / PM Peak

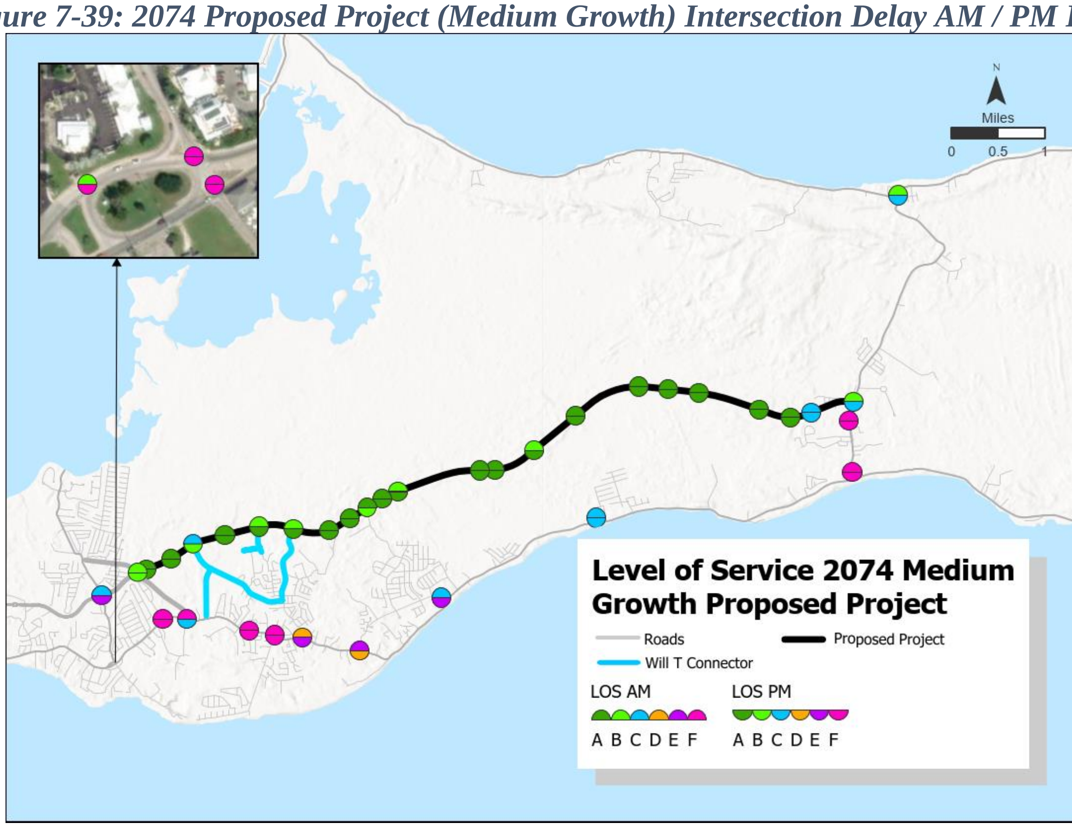


Figure 7-40: 2074 Future No-Build (High Growth) Intersection Delay AM / PM Peak

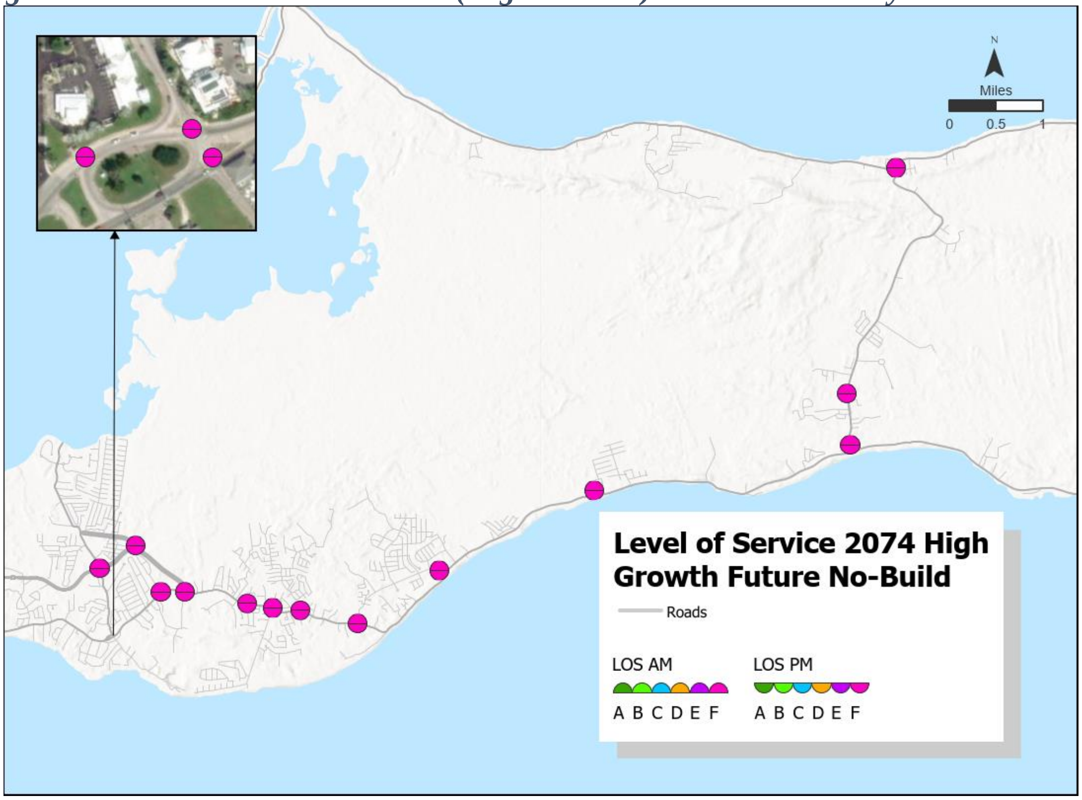


Figure 7-41: 2074 Proposed Project (High Growth) Intersection Delay AM / PM Peak

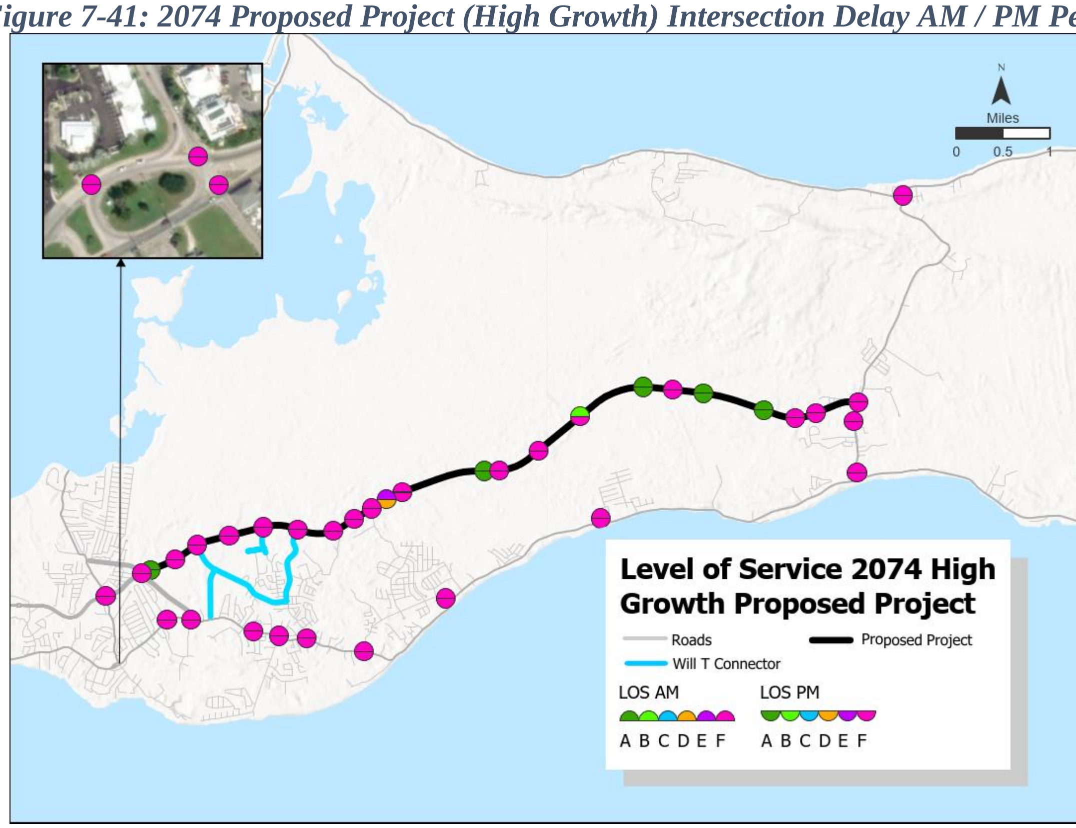


Table 7-16: 2074 Intersection Delay Summary Table Existing Intersections

#	Intersection	Level of Service (AM / PM)					
		2074 Future No-Build			2074 Proposed Project		
		Low	Medium	High	Low	Medium	High
100	EWA at Hirst Rd	F / F	F / D	F / F	A / A	C / E	F / F
200	Shamrock Rd at Hirst Rd	F / F	F / F	F / F	F / F	F / F	F / F
300	Shamrock Rd at Woodland Dr	E / E	F / F	F / F	F / F	F / F	F / F
400	Shamrock Rd at Agricola Dr	F / F	F / F	F / F	C / B	F / C	F / F
500	Shamrock Rd at Brightview Dr / Calla Lily Dr	F / F	F / F	F / F	D / E	F / F	F / F
600	Shamrock Rd at Beach Bay Rd	F / F	F / F	F / F	F / F	F / F	F / F
700	Shamrock Rd at Northward Rd	F / F	F / F	F / F	C / D	D / E	F / F
800	Shamrock Rd at Condor Rd	F / F	F / F	F / F	C / C	E / D	F / F
900	Bodden Town Rd at Bodden Town Bypass	F / F	F / F	F / F	C / D	C / E	F / F
1000	Bodden Town Rd at Long Fellow Dr	F / F	F / F	F / F	B / C	C / C	F / F
1100	Bodden Town Rd at Frank Sound Rd	F / F	F / F	F / F	F[1] / F[1]	F[1] / F[1]	F[1] / F[1]
1200	Frank Sound Rd at Clifton Hunter HS	F / F	F / F	F / F	F[1] / E[1]	F[1] / F[1]	F[1] / F[1]
1300	Frank Sound Rd at North Side Rd / Old Robin Rd	B / B	B / C	F / F	A / B	B / C	F / F

Table Note: Refer to **Figure 7-28** for map of intersection locations.

[1]LOS results shown are with mitigation improvements as discussed in **Section 7.5: Mitigation Measures**. Without mitigation, LOS results are worse than the Future No-Build.

Table 7-17: 2074 Intersection Delay Summary Table Proposed Intersections

#	Intersection	Level of Service (AM / PM)					
		2074 Future No-Build			2074 Proposed Project		
		Low	Medium	High	Low	Medium	High
1400	EWA at Agricola Dr Connector	E / C	C / A	F / F	A[1] / A[1]	B[1] / B[1]	F[1] / F[1]
1410	EWA at North Access Point #1 (east of Agricola Dr Connector)	-	-	-	A / A	A / A	A / A
1420	EWA at South Access Point #1 (east of Agricola Dr Connector)	-	-	-	A / A	A / A	F / F
1500	EWA at Will T Connector #1 / North Access Point #2	-	-	-	B / B	C / B	F / F
1510	EWA at U-Turn #1 (between Will T Connector #1 and #2)	-	-	-	A / A	A / A	F / F
1550	EWA at Will T Connector #2	-	-	-	B / A	B / A	F / F
1600	EWA at Northward Rd (Will T Connector #3)	-	-	-	B / A	B / A	F / F
1610	EWA at South Access Point #2 (east of Northward Rd)	-	-	-	B / A	A / A	F / F
1620	EWA at U-Turn #2 (west of Lookout Rd)	-	-	-	A / A	A / A	F / F
1700	EWA at Lookout Rd / North Access Point #3	-	-	-	A / B	A / B	F / F
1710	EWA at U-Turn #3 (east of Lookout Rd)	-	-	-	A / A	A / A	E / D
1720	EWA at South Access Point #3 (east of Lookout Rd)	-	-	-	A / A	B / A	F / F
1730	EWA at North Access Point #4 (near Meagre Bay Pond)	-	-	-	A / A	A / A	A / A
1740	EWA at U-Turn #4 (near Meagre Bay Pond)	-	-	-	A / A	A / A	F / F
1800	EWA at Long Fellow Dr (near Meagre Bay Pond)	-	-	-	B / A	B / A	F / F
1810	EWA at U-Turn #5 (near Meagre Bay Pond)	-	-	-	A / A	A / A	B / F
1820	EWA at North Access Point #5 (near Bodden Town District Line)	-	-	-	A / A	A / A	A / A
1830	EWA at South Access Point #4 (near Bodden Town District Line)	-	-	-	A / A	A / A	F / F
1840	EWA at U-Turn #6 (near Bodden Town District Line)	-	-	-	A / A	A / A	A / A
1850	EWA at North Access Point #6 (near Mastic Trail)	-	-	-	A / A	A / A	A / A
1900	EWA at Stepping Stone Dr (near Mastic Trail)	-	-	-	B / A	A / A	F / F
1910	EWA at North Access Point #7 (east of Mastic Trail)	-	-	-	B / C	C / C	F / F
2000	Frank Sound Rd at EWA	-	-	-	B / E	B / C	F / F

Table Note: Refer to **Figure 7-28** for map of intersection locations.

[1]LOS results shown are with mitigation improvements as discussed in **Section 7.5: Mitigation Measures**. Without mitigation, LOS results are worse than the Future No-Build.

7.4.6.6 Intersection Delay Summary of the Proposed Project

When evaluating LOS, the Proposed Project is anticipated to perform well in 2026, with large-scale infrastructure improvements but minor traffic growth; conversely in 2074, the Proposed Project is largely working with the same infrastructure in the study area, but with much more traffic growth. The intervening years all exhibit acceptable intersection delay along the Proposed Project, with some locations showing steady decline, especially along the existing roadway network.

To assess the ability to travel locally within Bodden Town and the EWA EIA study area, LOS was examined during both the 6:00 to 7:00 AM and 5:00 to 6:00 PM peak hours to determine the worst-case peak for each study area intersection; a percentage of intersections performing acceptably at LOS D or better was then calculated for both peak hours for all study years (**Table 7-18**). This evaluation considered the conditions of these intersections under the Future No-Build and the Proposed Project.

Table 7-18: Percentage of Intersections Performing at LOS D or Better (2026 through 2074)

% Performing at LOS D or Better	Future No-Build	Proposed Project
2026: Based on worst-case peak hour (AM or PM)	64%	100%
2036: Based on worst-case peak hour (AM or PM)	21%	94%
2046: Based on worst-case peak hour (AM or PM)	29%	92%
2074 (Low Growth): Based on worst-case peak hour (AM or PM)	7%	78%
2074 (Medium Growth): Based on worst-case peak hour (AM or PM)	14%	69%
2074 (High Growth): Based on worst-case peak hour (AM or PM)	0%	14%

Source: Grand Cayman Travel Demand Model & Associated Operational Model

In 2026, the Future No-Build is expected to have approximately 64% of intersections performing at LOS D or better whereas the Proposed Project is expected to have 100% of intersections performing at LOS D or better based on worst-case peak hour.

By 2036, just 21% of the Future No-Build network is expected to perform at LOS D or better, while the Proposed Project continues to perform well at 94% of all intersections.

In 2046, 29% of the Future No-Build network is projected to work at LOS D or better, and the Proposed Project will perform acceptably for 92% of intersections. The slight increase in acceptable intersection delay in the 2046 Future No-Build is due to traffic rerouting away from the intersection of EWA and Hirst Road; as traffic volumes increase, some routes become overly congested, and vehicles instead seek out other paths with less friction, resulting in occasional, isolated situations exhibiting improved intersection delay.

In 2074 (Low Growth), the Future No-Build is expected to have approximately 7% of intersections performing acceptably; this indicates that many intersections within the study area are expected to have high delay, systemic breakdowns, long queues, and/or slow travel. The Proposed Project is anticipated to have 78% of intersections working acceptably at LOS D or better in the worst-case peak hour.

In 2074 (Medium Growth), 14% of the Future No-Build will operate acceptably. The Proposed Project is projected to have 69% of intersections performing acceptably at LOS D or better in the worst-case peak hour. The existing intersections expected to show the most improvement in intersection delay include those at and east of Bodden Town Road at Bodden Road Town Bypass (intersection 900 in **Figure 7-28**).

In 2074 (High Growth), 0% of the Future No-Build is expected to perform acceptably. The Proposed Project is also anticipated to degrade significantly with 14% of intersections working acceptably at LOS D or better in the worst-case peak hour.

7.4.7 Safety

The Proposed Project is expected to provide safety improvements to the current state of travel to and from the eastern side of the island. Today, drivers utilise Shamrock Road, Bodden Town Road, and Frank Sound Road to traverse the island. Those facilities are all two-lane, undivided roadways, with speed limits as high as 50 mph. High-speed travel with vehicles traveling in opposite directions just feet apart is less than ideal from a safety perspective, and is further compounded by the number of cross-streets and driveways found throughout the roadway network. With traffic volumes that are high today and projected to increase in the future, motorists can become frustrated and aggressive, further reducing road safety.

The Royal Cayman Islands Police Service (RCIPS) provided a compilation of motor vehicle accident statistics in Grand Cayman by district from 2012 to 2022, as well as a list of road fatalities from 2018 to 2020. However, this data was insufficient to conduct a detailed quantitative safety analysis for this project.

The US Federal Highway Administration (FHWA) has developed crash modification factors (CMFs) to determine how well various improvements affect crash rates. The methodology behind the development of any CMF is to compare the number of crashes at a given location before and after the improvement was implemented. In this way, a CMF can be calculated that will give a potential reduction in crashes, though every situation differs due to roadway geometries and driver characteristics. Nevertheless, CMFs are an excellent way to gauge how well a roadway improvement will improve safety and are a key component of any Highway Safety Manual (HSM) analysis. The HSM uses a technical approach to quantify safety impacts when planning roadways, or when evaluating intersection delay, design, or maintenance. However, due to limited crash data availability, a qualitative discussion of CMFs (**Appendix G.4: Crash Modification Factors**) can help to provide some insights into potential crash reductions that may results from the construction of the Proposed Project.

The new EWA Extension will be a safer facility for all road users. The new facility will be a divided roadway, which removes the possibility of high-speed vehicles traveling in opposite directions crashing into each other, therefore preventing or eliminating head-on collisions. CMFs suggest that adding a median barrier can reduce crashes by over 80%. The new road will be context-sensitive and will seek to minimise its footprint but will be designed with anticipated traffic volumes in mind. The number of lanes constructed along the EWA will be added in phases based on the forecasted traffic growth and the anticipated capacity needed to perform acceptably based on HCM thresholds. Where volumes are projected to exceed capacity of a two-lane road, the EWA will be constructed as a four-lane facility, which will double the capacity of the roadway and reduce driver frustration. CMFs indicate that doubling a road from two to four lanes could reduce crashes by over 60%.

Another key feature of the new roadway is the limitation of cross-streets and driveway access points. As discussed previously, only a small number of cross-streets will be allowed to intersect with the new EWA extension, creating a "limited access" roadway. True limited access roadways, such as freeways, are only accessible via interchanges, which are typically spaced several miles apart. The EWA will utilise only a handful of cross streets, which will then feed into other local roads, thus reducing friction on the corridor. Similarly, driveways will be limited on the EWA, featuring left-in/left-out access to minimise conflict points. U-turn locations will be spaced adequately along the EWA to prevent vehicles from having to traverse several miles in the wrong direction to reach the next cross street before backtracking to their destination. This access control is expected to enhance safety by reducing friction points along the extension. CMFs show that the absence of access points could reduce crashes by over 40%.

For non-vehicular traffic, such as pedestrians and bicyclists, the Proposed Project will likely also be a safety boon. Sidewalks will be included, providing a physically separated facility that non-motorized road users can utilise. Today, no such facilities exist along the roadway network, and at times shoulder widths are so small that pedestrians and bicyclists must use the outside edge of the travelled way. Not only does this present a risk of being struck by a vehicle traveling in the same direction, but it also causes vehicles to shy away from the shoulder, toward the roadway centreline and toward oncoming traffic. CMFs suggest that installing a sidewalk may lead to a reduction in crashes of over 40%.

At the intersection level, the installation of roundabouts at either end of the Proposed Project is anticipated to result in safer performance. Roundabouts require all vehicles to yield, including the mainline movements. Today, the mainline movements are free flow, with side streets working as stop-controlled intersections. Therefore, side street traffic must wait for an acceptable gap in traffic to enter the mainline. As delay increases and drivers become more frustrated, drivers may accept smaller gaps, leading to dangerous manoeuvres that cut off mainline traffic. Requiring all vehicles to pause before entering an intersection provides an opportunity for all approaching vehicles to enter the intersection safely. CMFs vary depending on the configuration of the roundabout – for example, one lane circulating versus multiple lanes circulating – but the CMFs show a decrease in crashes of anywhere from 5% to 70%, depending on the local context.

At intersections without roundabouts, left-in/left-out intersections will be installed as part of the Proposed Project. Under this setup, side street traffic will instead only have to contend with one direction of mainline volume and will only be making left turns. CMFs suggest that crashes could be reduced by 45% when comparing a full movement stop-controlled intersection to a left-in/left-out intersection.

7.4.7.1 Roadway Conflict Points

As discussed in the Longlist Alternatives Evaluation, dated September 6, 2023, a desired benefit of new roadway alignments included the reduction of cross-street intersections on the primary east-west corridor, and the reduction of driveway access points on the primary east-west corridor. Conflict points occur when two objects (e.g., vehicle/vehicle, pedestrian/pedestrian, vehicle/pedestrian, etc.) try to occupy the same space at the same time. As stated in the AASHTO publication *A Policy on Geometric Design of Highways and Streets,* "Elimination or minimisation of crossing and turning conflicts can be very effective in reducing crash frequency, especially at intersections." More access points (e.g., cross-street intersections and driveways) along a roadway create more conflict points as vehicles enter and exit the roadway. People travelling along a corridor create opportunities for crashes at these conflict points, so roadways with higher traffic volumes result in more potential for conflicts.

As shown below in **Table 7-19**, utilising the Proposed Project as the primary east-west corridor (instead of the existing coastal road) would reduce the number of cross-street intersections and driveway access points that motorists would have to pass by at least 75%. This is a result of bypassing the developed areas along Hirst Road, Shamrock Road, and Bodden Town Road and passing primarily through undeveloped areas.

Table 7-19: Cross Street Intersection and Driveway Access Points Comparison

	Future No-Build	Proposed Project
Cross Street Intersection Reduction	No reduction	75-100% reduction*
Driveway Access Point Reduction	No reduction	75-100% reduction*

*Using the Proposed Project as the primary east-west corridor (instead of the existing coastal road) would reduce the number of cross-street intersections and driveway access points that motorists would have to pass by at least 75%.

As previously discussed, adding a parallel route to the existing east-west road will more than double the existing capacity for vehicles to move from one end of the island to the other. Noting that the new facility will have more lanes, reduced access points, a median divider, and sidewalks, it is expected that a large portion of the existing traffic will be rerouted onto that facility. This has the secondary benefit of reducing the amount of traffic on the existing roadways. While there will still be a high number of cross streets and driveways on the existing roadways, the mainline free-flow volume will be substantially lower, reducing friction and allowing side-street traffic to enter the roadway network with less delay and frustration.

The Proposed Project reduces conflict points for the full length of the EWA Extension, with fewer chances for vehicles to cross paths. The new alignment will feature a median with a full barrier, as well as dedicated transit and bicycle/pedestrian facilities. Two major intersections on the new alignment will be roundabouts, which are safer than stop and signal-controlled intersections, and the remaining stop-controlled intersections will only interact with one direction of traffic flow as partial access left-in/left out intersections, minimising conflicts.

7.4.8 Multimodal Access

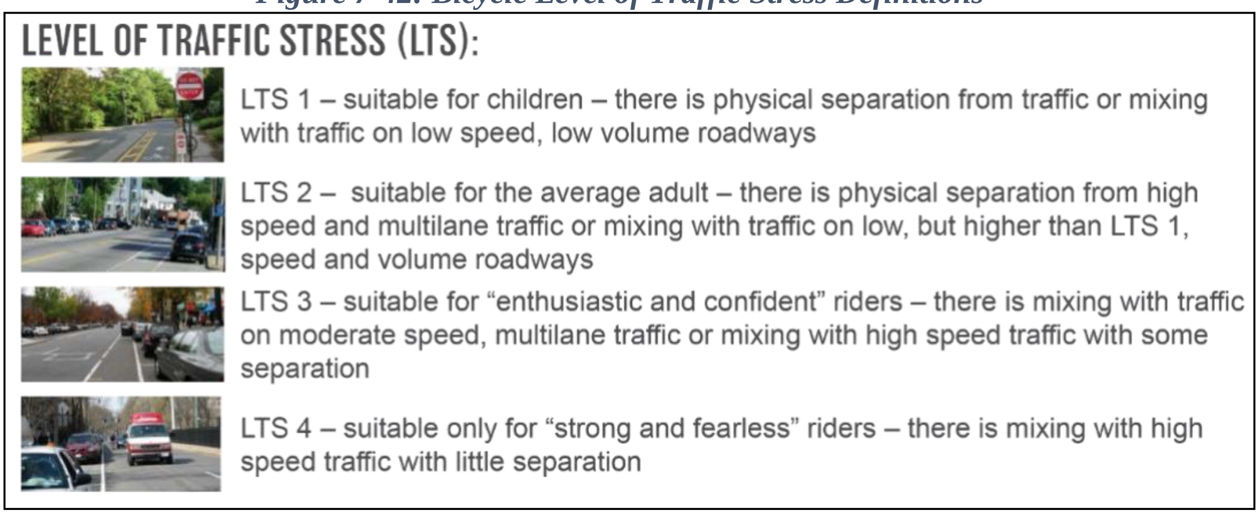
An important aspect of the Proposed Project is the potential accessibility improvement for all modes of travel, including pedestrians, bicyclists, and micromobility options. Micromobility refers to any small, low-speed (typically less than 30 mph), electric-powered transportation devices such as electric bikes or electric scooters. By providing amenities such as sidewalks, micromobility paths, and dedicated transit lanes, the EWA will improve access and mobility for all users, including those who do not own personal vehicles.

Under Baseline Conditions, Shamrock Road and Bodden Town Road often experience vehicular traffic congestion but lack consistent sidewalks, creating unsafe conditions for pedestrians and drivers alike. **Figure 7-6** illustrates a lack of sidewalk and/or bicycle facilities as well as inconsistent shoulder provisions on either side of Bodden Town Road near Frank Sound Road, demonstrating a need for separated pedestrian and bicycle facilities. The following sections will discuss the Proposed Project's anticipated improvements for walk, bicycle, and micromobility accessibility.

7.4.8.1 Bicycle Level of Traffic Stress

Level of Traffic Stress (LTS) is a performance measure that ranks how suitable roadway facilities are for bicycle access. LTS considers the roadway's bicycle infrastructure alongside traffic volume, traffic speeds, and number of lanes. Each facility is ranked on a scale of 1 to 4, with 1 being the most suitable for bicycle access and 4 being the least, as shown in **Figure 7-42**.

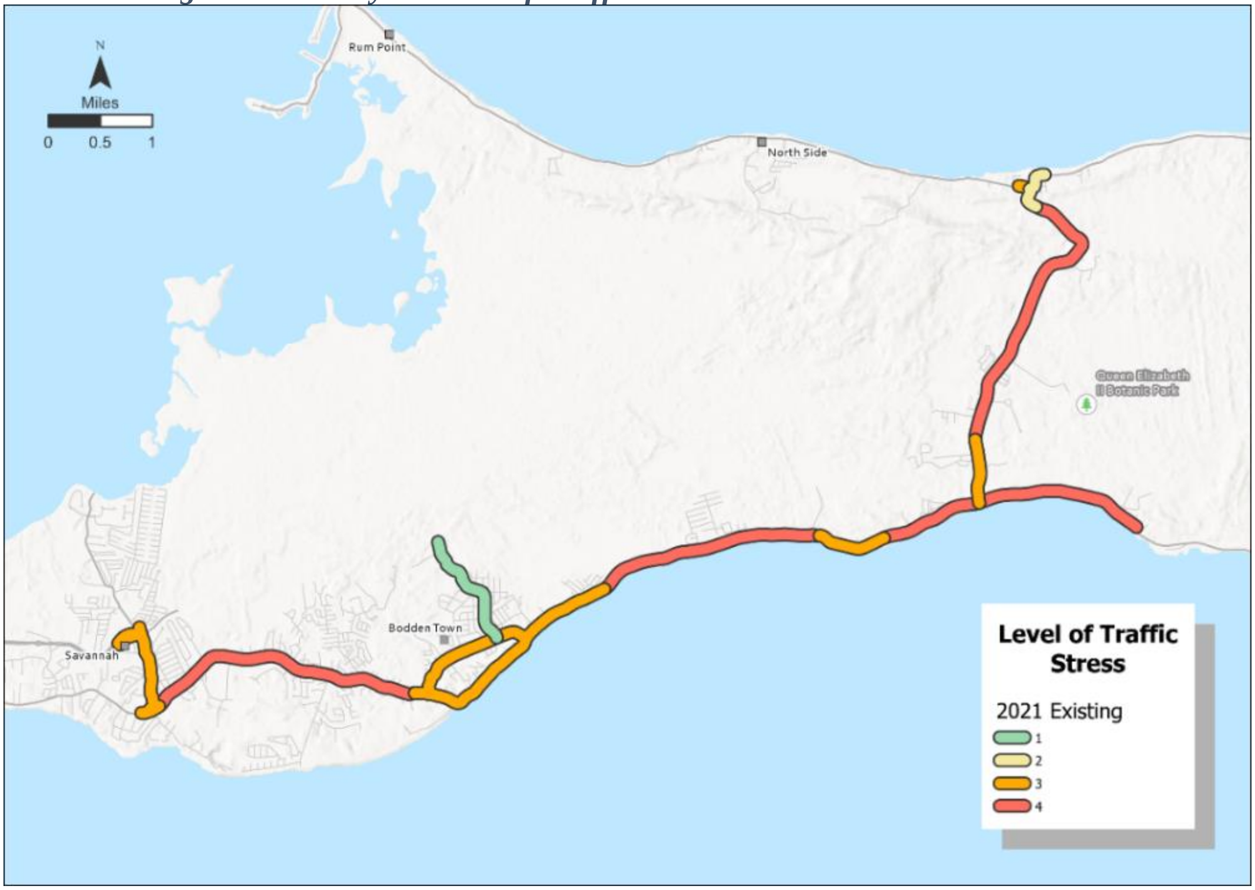
Figure 7-42: Bicycle Level of Traffic Stress Definitions



Source: Furth & Putta (2016), *Visualizing and Measuring Low-Stress Bicycle Network Connectivity in Delaware*

The study area was evaluated for LTS under Baseline Conditions, as shown in **Figure 7-43**. Under Baseline Conditions, Hirst Road, Shamrock Road, Bodden Town Road, and Frank Sound Road are classified as LTS 3 or 4 due to a combination of high speeds, high volumes, and lack of bicycle facilities.

Figure 7-43: Bicycle Level of Traffic Stress – 2021 Baseline Conditions

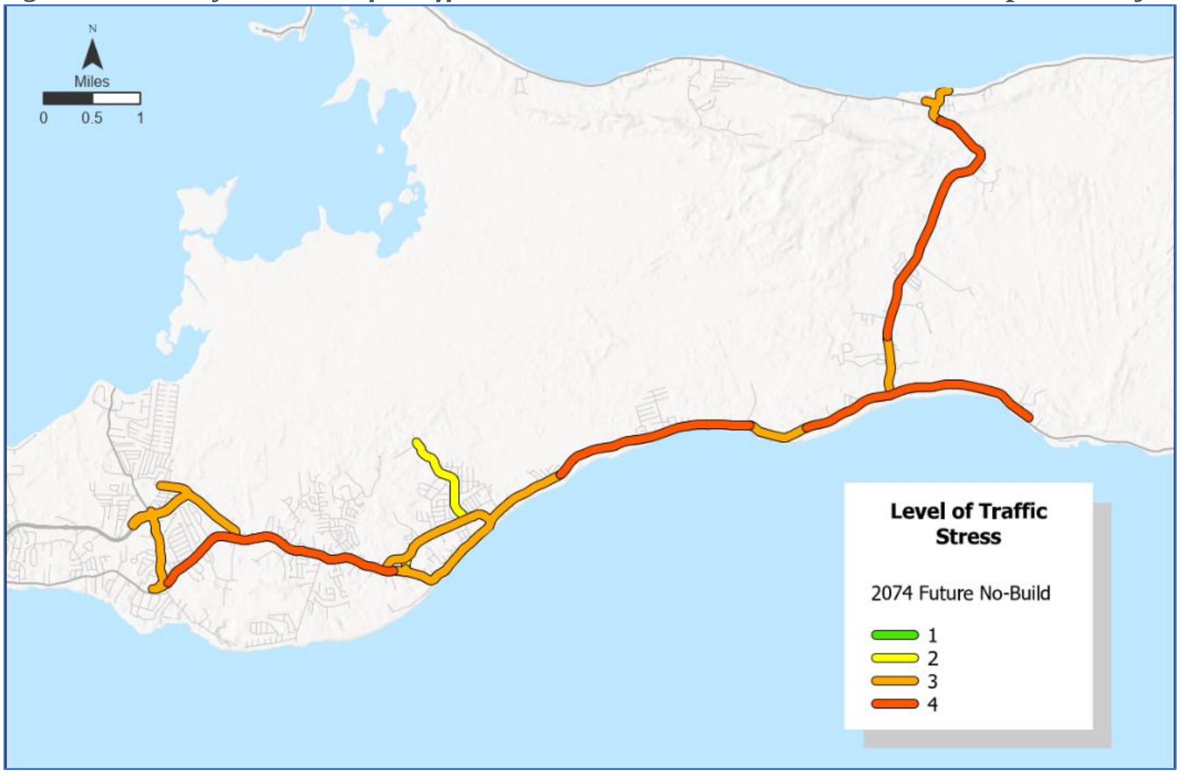


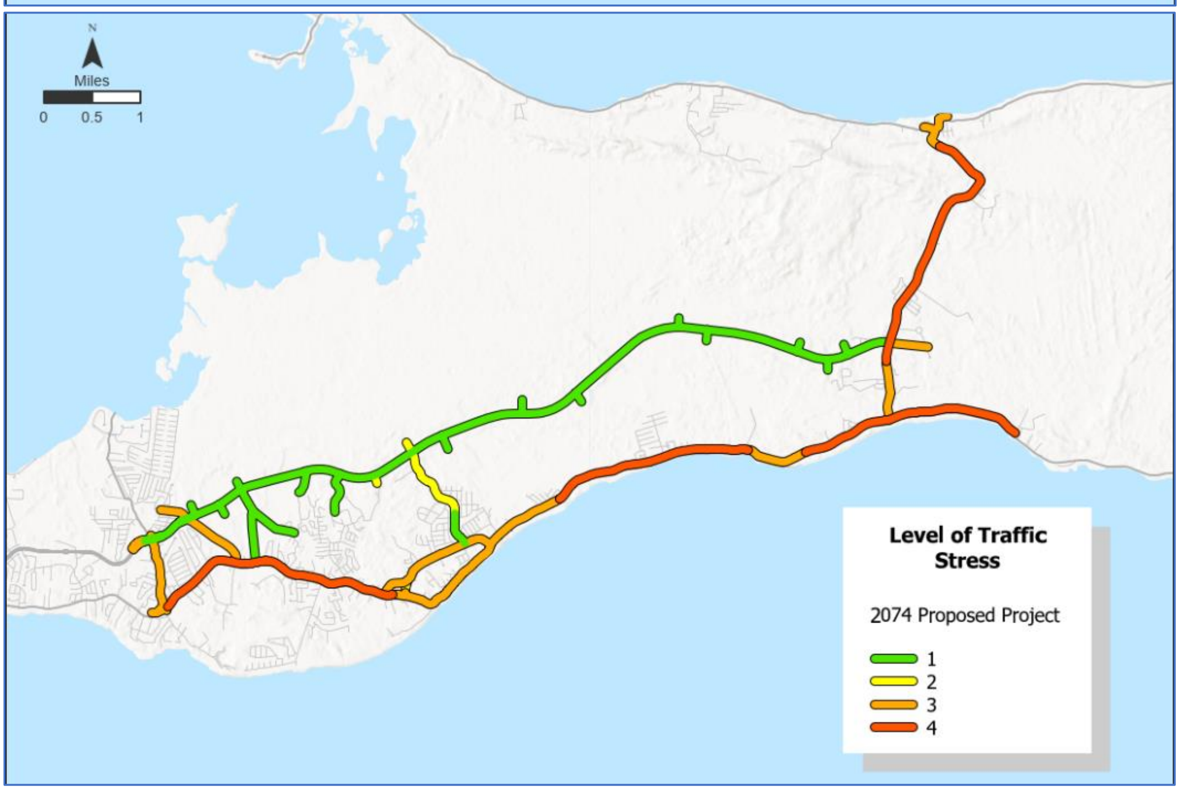
Bicycle facilities including bike lanes, sidewalks, and micromobility paths will be constructed for the Proposed Project as follows:

- By 2036, sidewalks and micromobility paths will be constructed along the EWA Sections 1 and 2 between Hirst Road and Lookout Road.
- By 2046, sidewalks and micromobility paths will be constructed along the EWA Sections 1, 2, and 3 between Hirst Road and Frank Sound Road.

LTS is shown for the 2074 Future No-Build and the Proposed Project in **Figure 7-44**. When separated sidewalks and micromobility paths are installed, the EWA will become a LTS 1 facility, significantly improving bicycle access between Hirst Road and Frank Sound Road. Under the Proposed Project, the full limits of the EWA between Hirst Road and Frank Sound Road will become a LTS 1 facility by 2046, providing separated sidewalks and multi-use paths for bikes and other micromobility modes of travel. This would provide a LTS 1 facility to connect residential neighbourhoods, businesses, schools, and parks located between Frank Sound Road and Hirst Road.

Figure 7-44: Bicycle Level of Traffic Stress – 2074 Future No-Build and Proposed Project





From top to bottom: 2074 No-Build, Proposed Project

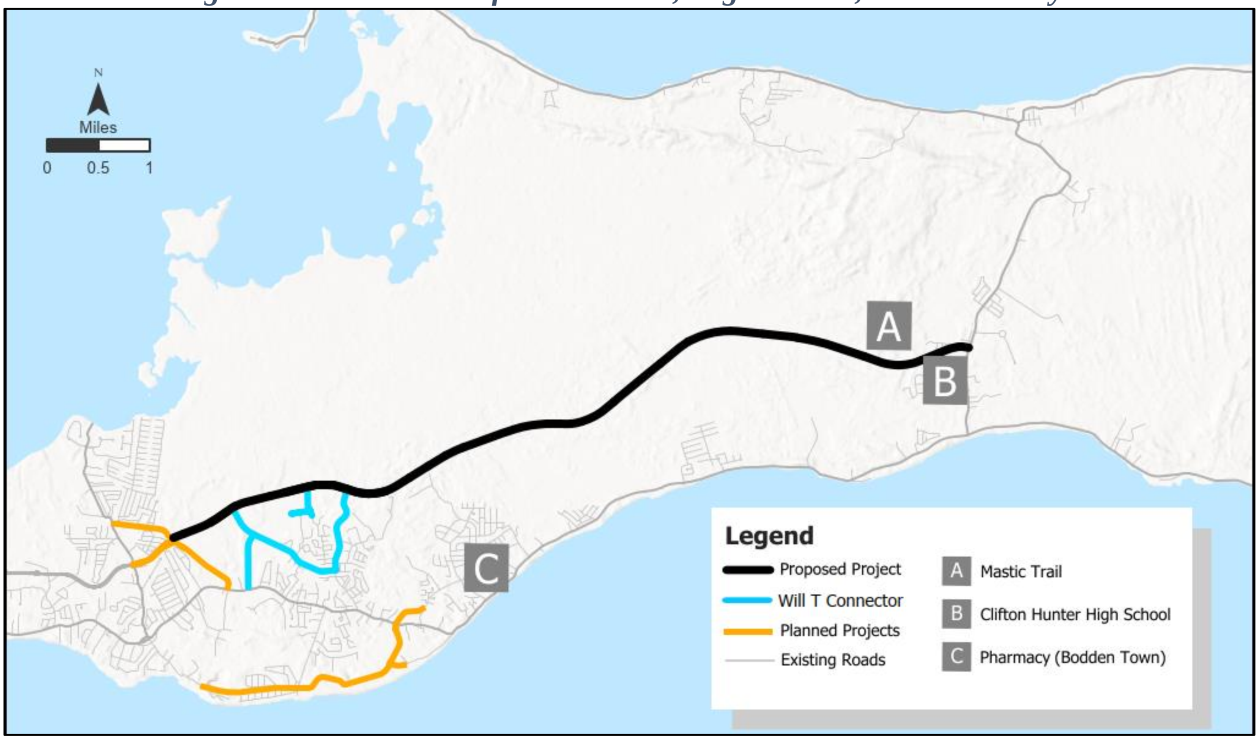
Figure note: Bodden Town Road segments are shown as LTS 3 in the Future No-Build and the Proposed Project due to stretches of reduced speed limits (see **Figure 7-3**).

7.4.8.2 Non-Vehicular Access

Accessibility for pedestrians, bicycles, and micromobility modes can be evaluated by determining how many people would have access to various locations using these modes of travel. To assess the Proposed Project's impact on non-vehicular accessibility, particular consideration was given to the following locations (**Figure 7-45**), which were selected to represent community centres that many eastern district residents would need or desire access to:

- The Mastic Trail southern trailhead, which is situated in the Mastic Reserve near Frank Sound Road and provides access to one of Grand Cayman's natural heritage sites.
- Clifton Hunter High School located on Frank Sound Road.
- The Valu-Med Pharmacy located on Anton Bodden Drive in Bodden Town.

Figure 7-45: Location of Mastic Trail, High School, and Pharmacy



Access to these three locations was evaluated for walk, bicycle, and micromobility modes based on the following criteria:

- Walk accessibility evaluates how long it would take to walk to each location using only sidewalks or LTS 1 facilities.
- Bicycle accessibility evaluates how long it would take to bike to each location using only LTS 1 or LTS 2 facilities.
- Micromobility accessibility evaluates how long it would take to travel using a micromobility vehicle (such as electric bikes or electric scooters) to each location using only LTS 1 or LTS 2 facilities.

As shown in **Figure 7-46** through **Figure 7-48**, access to these points of interest was evaluated by determining the projected 2074 population that would be able to reach these locations within a 30-minute walk, bike, or micromobility commute. These locations are each accessible via the proposed EWA alignment, so access significantly improves with construction of the Proposed Project.

Figure 7-46: Potential Non-Vehicular Access to Mastic Trail

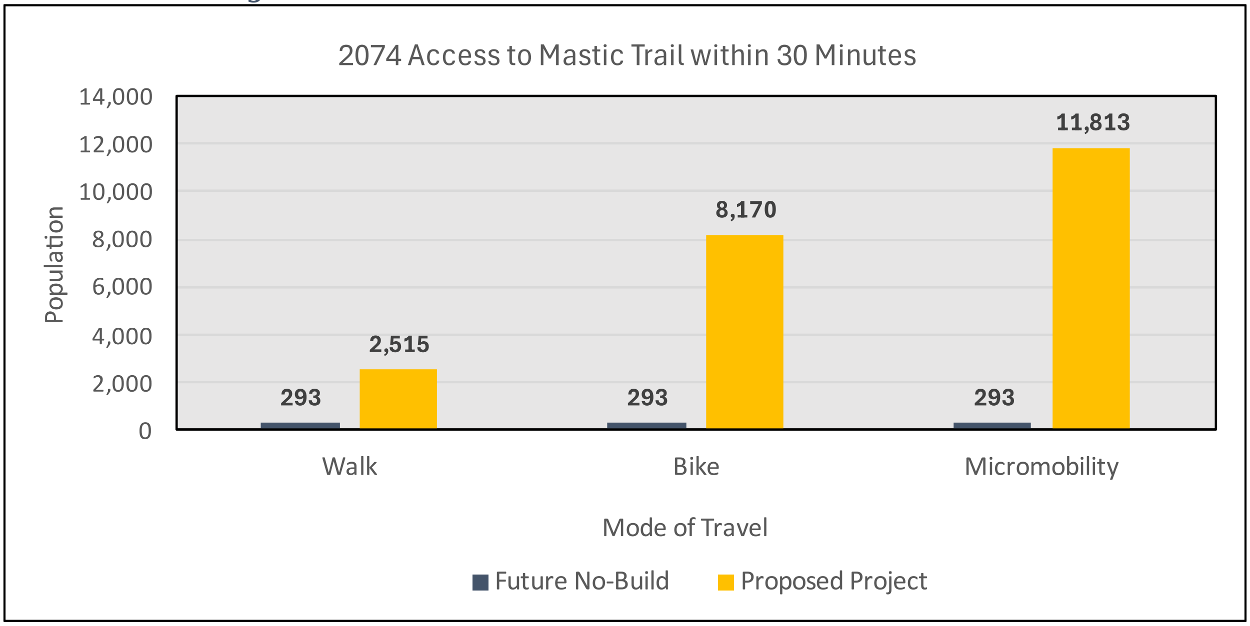


Figure 7-47: Potential Non-Vehicular Access to Clifton Hunter High School

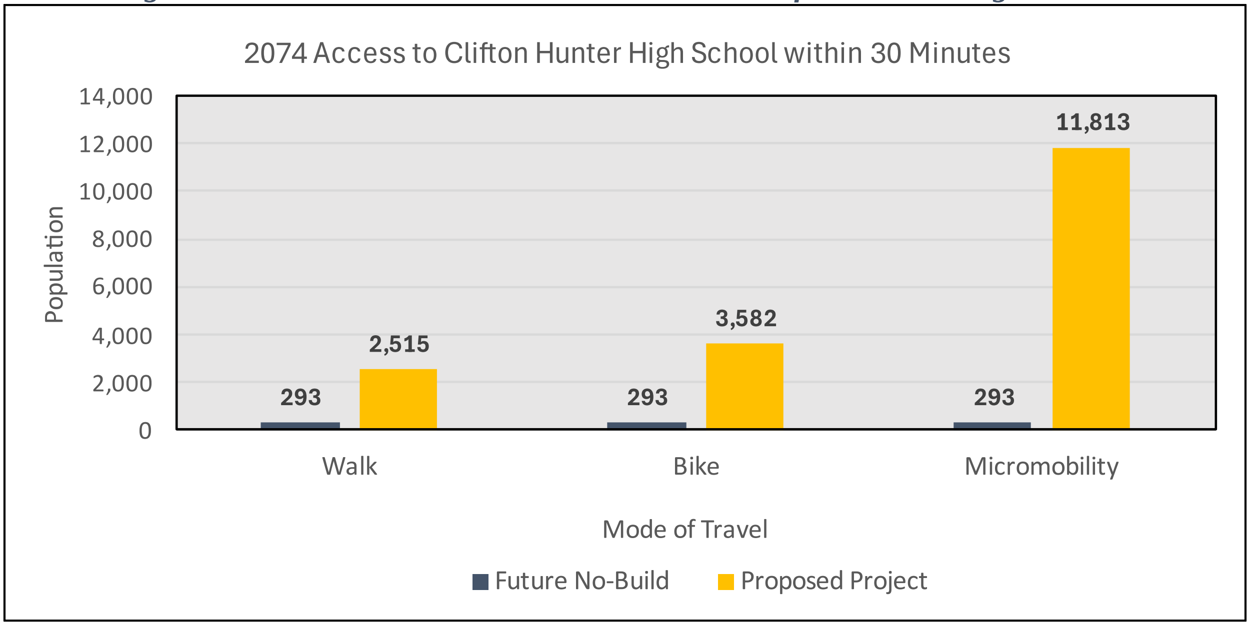


Figure 7-48: Potential Non-Vehicular Access to Pharmacy

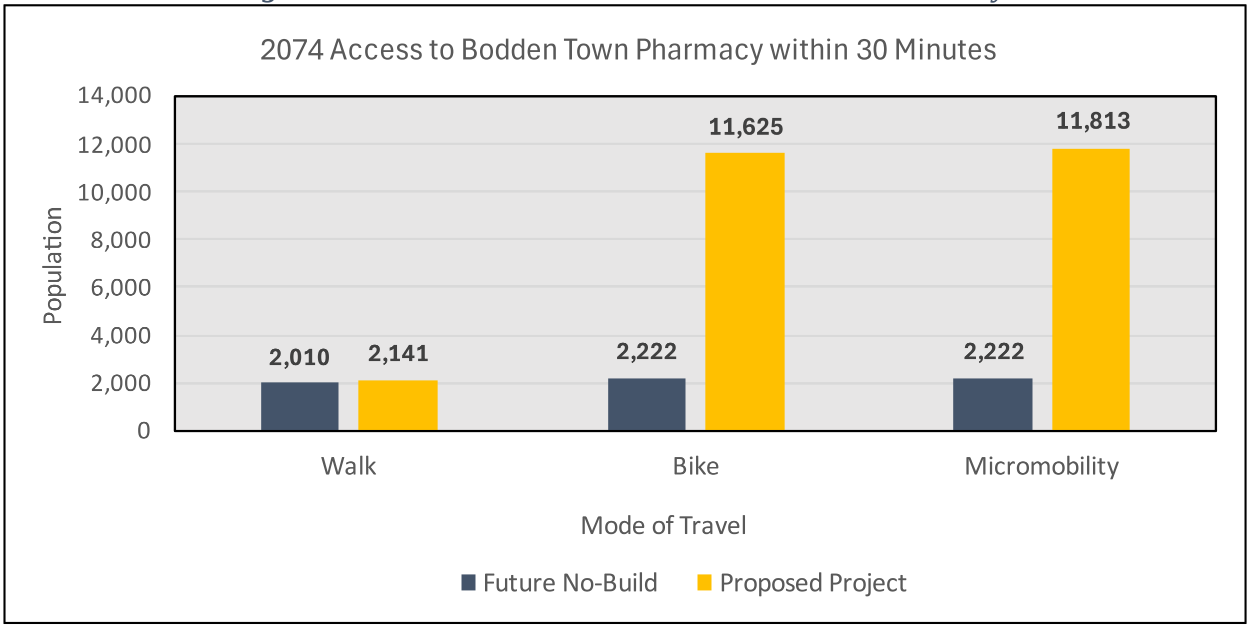
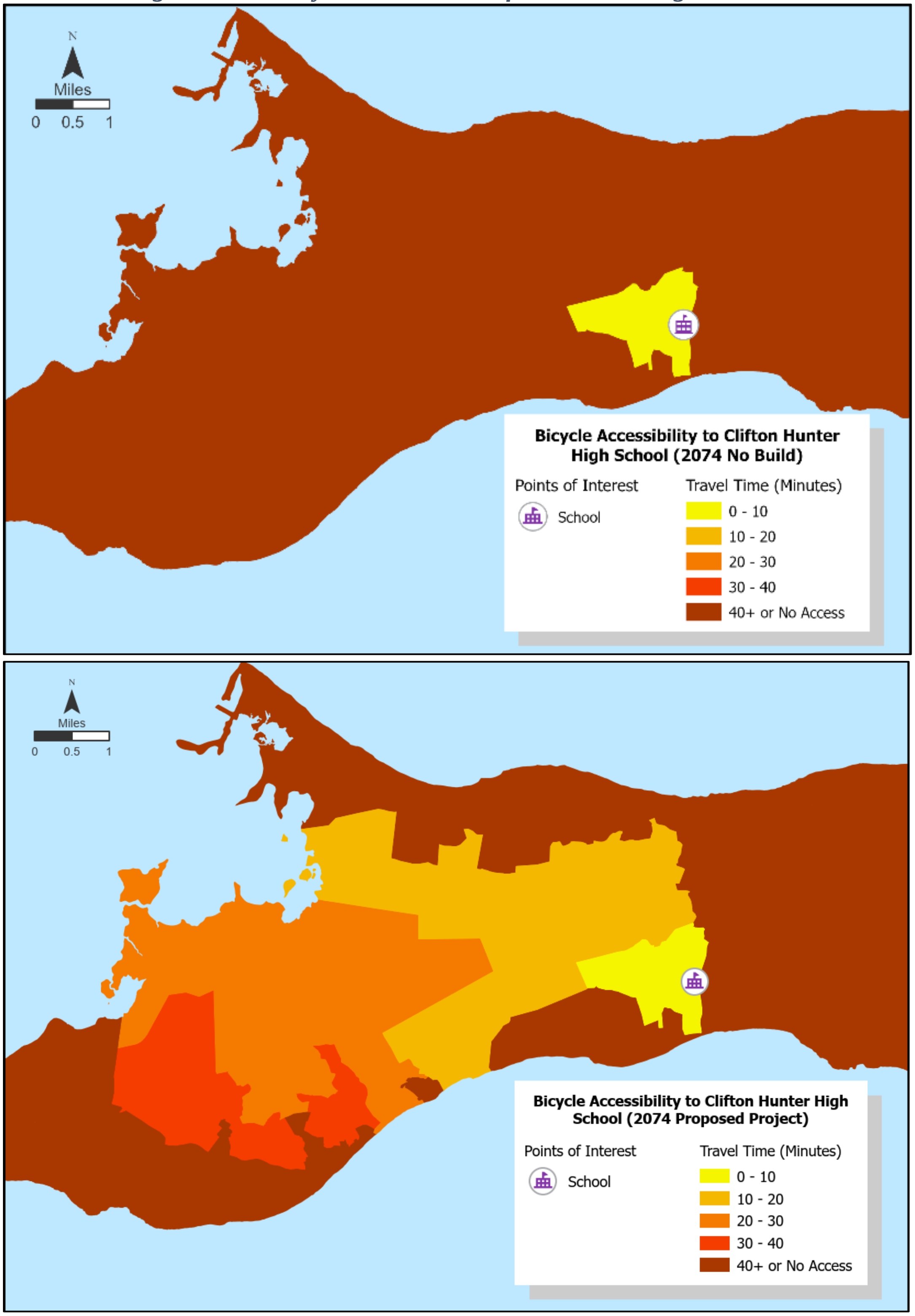


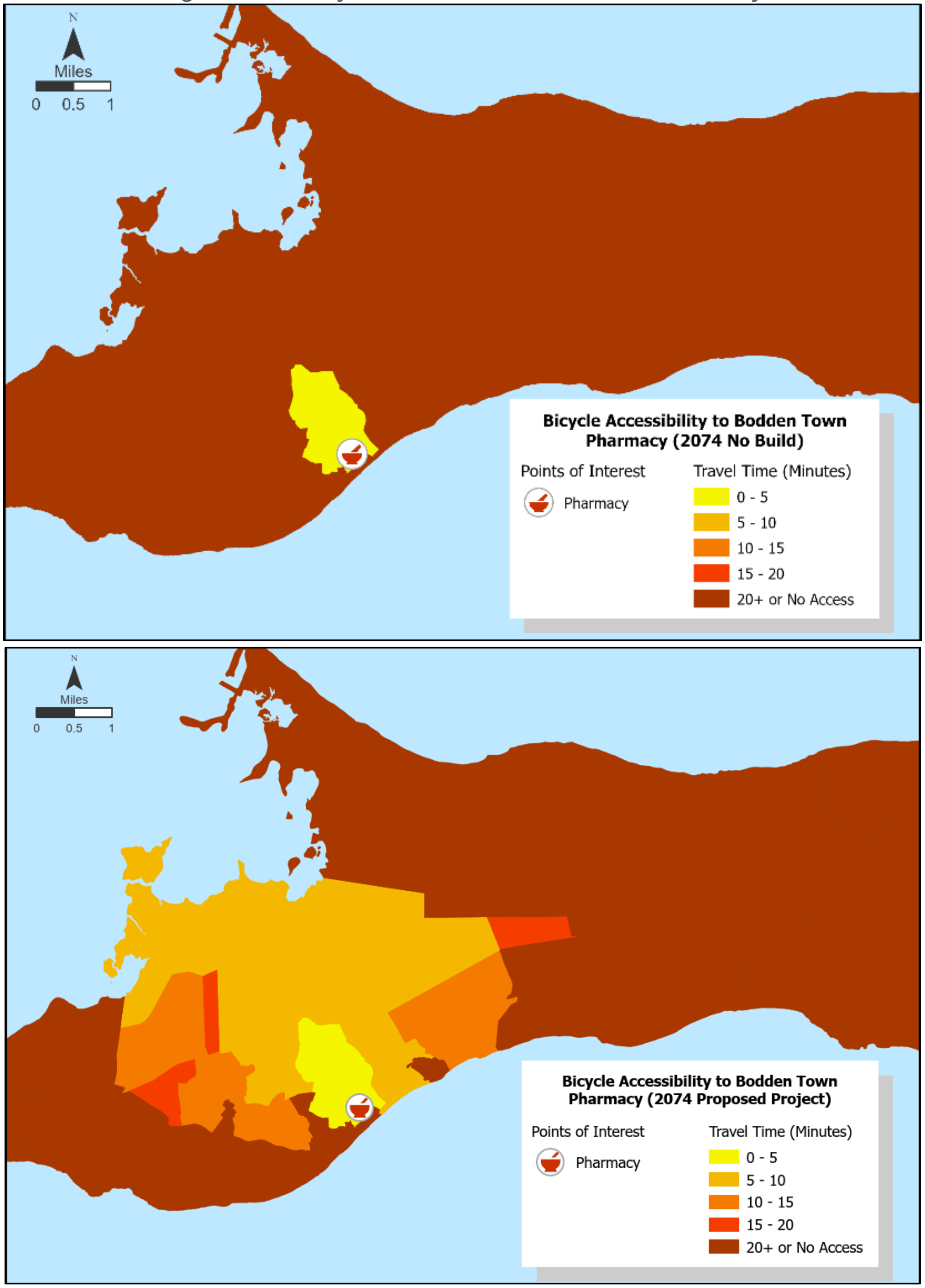
Figure 7-49 through **Figure 7-51** illustrate anticipated walk and bicycle access to key destinations as travel time contour maps, visually mapping how access changes under the Proposed Project based on the LTS criteria previously described in this section. These maps provide an interpretation of each alternative's quantitative LTS data (**Figure 7-44**) and are only a representative sample to demonstrate how improvements in walk/bicycle accessibility may impact the quality of life for residents of the eastern districts. The Proposed Project provides significantly improved access to the Mastic Trail, Clifton Hunter High School, and the Bodden Town Pharmacy.

Figure 7-49: Bicycle Access to Clifton Hunter High School



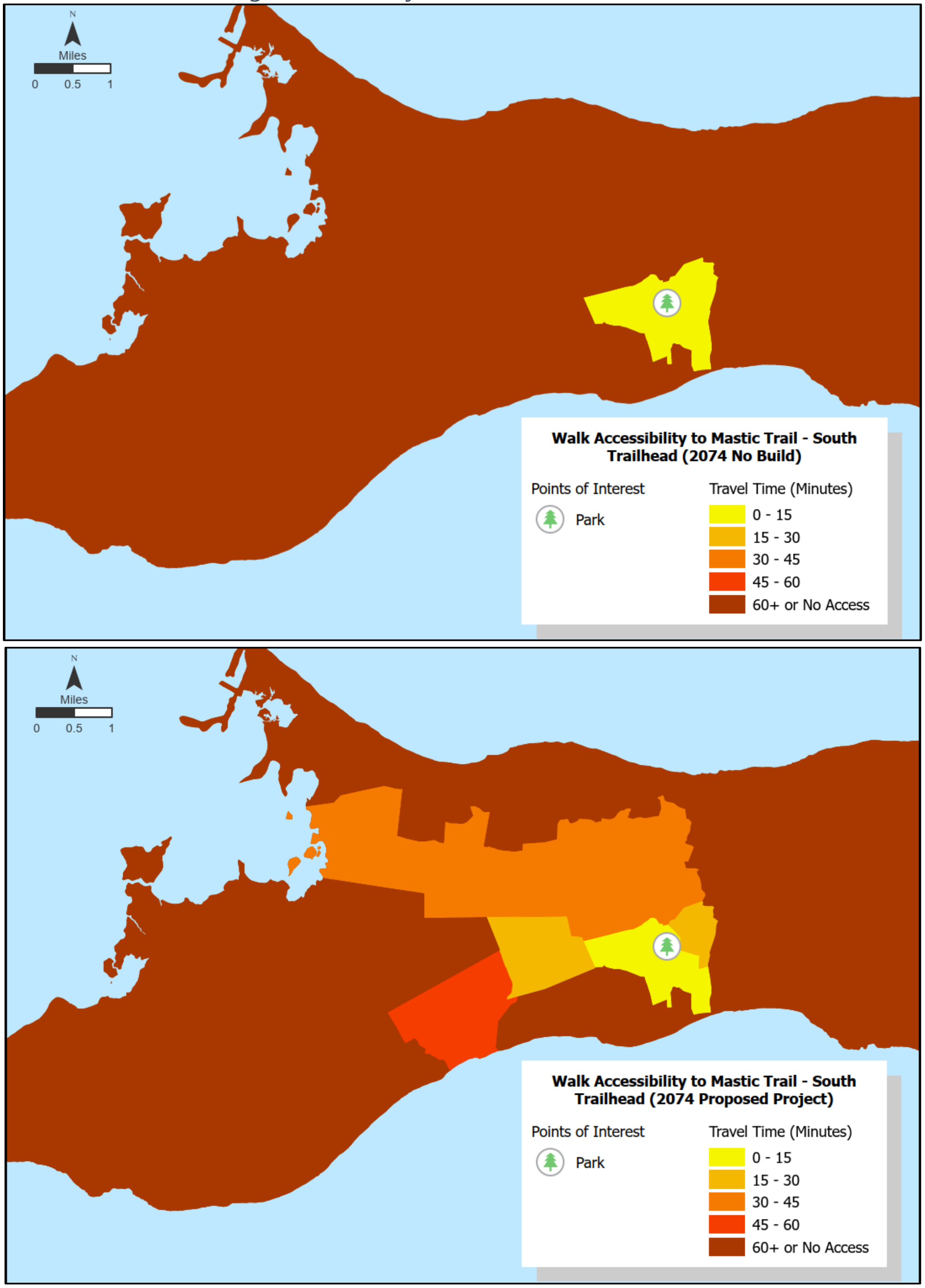
From top to bottom: 2074 No-Build, Proposed Project

Figure 7-50: Bicycle Access to Bodden Town Pharmacy



From top to bottom: 2074 No-Build, Proposed Project

Figure 7-51: Bicycle Access to Mastic Trail



From top to bottom: 2074 No-Build, Proposed Project

7.4.9 Critical Success Factor Impact Summary

The Proposed Project was assessed in terms of the CSFs that were established based on the ToR, using the Future No-Build conditions as a basis to compare the potential transportation impacts of the Proposed Project. The CSFs encompass factors including resiliency, access to jobs, travel times, safety, and multimodal accessibility (**Table 7-4**). The Proposed Project will positively impact many of these existing transportation concerns. These impacts are summarized with respect to the CSF criteria in **Table 7-20**, evaluating the Proposed Project's anticipated benefits on a 4-point qualitative scale.

UK WebTAG guidance does not provide specific thresholds to evaluate these transportation and mobility components, so the criteria to qualitatively evaluate the Proposed Project were derived from multiple sources: some are based on thresholds outlined in **Appendix A – Longlist [Alternatives] Evaluation**, other thresholds have been updated for the Proposed Project evaluation using data from the GCM, and some were refined to better align with scaling used in **Chapter 8: Socio-Economics**. Based on these CSF thresholds, the Proposed Project is anticipated to achieve a "Large Beneficial" transportation impact overall, with anticipated benefits detailed in **Table 7-20**.

Table 7-20: Critical Success Factor Impact Summary

CSF Criteria	CSF Thresholds	Project Impacts
a. **Alternative Routes:** Create an alternative travel route to the existing two-lane Bodden Town Road	• **Large Beneficial:** Consists of 100% new roadway connection between Woodland Drive and Frank Sound Road. • **Moderate Beneficial:** Consists of 75% to 99% new roadway connection between Woodland Drive and Frank Sound Road. • **Slight Beneficial:** Consists of 1% to 74% new roadway connection between Woodland Drive and Frank Sound Road. • **Neutral:** Provides no new roadway connection between Woodland Drive and Frank Sound Road.	**Large Beneficial:** The Proposed Project provides an alternate route to the existing coastal road in the event of road closures, flooding, and other emergency events along the coastal road, consisting of 100% new roadway connection between Woodland Drive and Frank Sound Road.
b. **Existing Roadway Resiliency:** Improve resiliency of the existing roadway travel route between North Side/East End and George Town/West Bay.	• **Large Beneficial:** Reduces existing road volume by at least 50%. • **Moderate Beneficial:** Reduces existing road volume by 25% to 49%. • **Slight Beneficial:** Reduces existing road volume by 10% to 24%. • **Neutral:** Reduces existing road volume by less than 10%.	**Large Beneficial:** The Proposed Project is projected to shift more than 50% of east-west traffic to the safer EWA facility, proportionally reducing the number of crashes and resulting road closures that would occur along the existing coastal road.
c. **Future Traffic Demand:** Support current and future traffic demand.	• **Large Beneficial:** Provides access for at least 16% more traffic volume. • **Moderate Beneficial:** Provides access for 6% to 15% more traffic volume. • **Slight Beneficial:** Provides access for 2 to 5% more traffic volume. • **Neutral:** Provides access for 0 to 1% more traffic volume.	**Large Beneficial:** The Proposed Project is projected to relieve congestion along the existing coastal road by shifting east-west traffic to the EWA facility, accommodating longer distance commutes for residents in eastern districts traveling to employment opportunities in western districts. The Proposed Project will provide access to over 16% more traffic volume on average across all analysis years.
d. **Commuter Travel Times:** Improve travel time between North Side/East End and George Town/West Bay	• **Large Beneficial:** Reduces peak direction travel time by more than 25%. • **Moderate Beneficial:** Reduces peak direction travel time by 15% to 24%. • **Slight Beneficial:** Reduces peak direction travel time by 5% to 14%. • **Neutral:** Reduces peak direction travel time by 0% to 4%.	**Moderate / Large Beneficial:** The Proposed Project is expected to improve travel times compared to Future No-Build conditions by more than 25% between Frank Sound Road and Hirst Road. The new corridor is also expected to improve travel times from east Bodden Town, North Side, and East End to key points in George Town/West Bay such as the airport, hospital, and Camana Bay by between 15% to 25% on average across all analysis years when compared to Future No-Build conditions.

CSF Criteria	CSF Thresholds	Project Impacts
e. **Utilities:** Accommodate utility expansion (electricity, fibre, water, central sewage) *	• **Opportunity to Accommodate:** Design provides opportunity to accommodate utilities. • **No Accommodation:** Design does not provide opportunity to accommodate utilities.	**Opportunity to Accommodate:** The Proposed Project includes provisions to accommodate utilities such as sanitary sewer, water, fibre optics, and electricity. Discussion of utilities is included in the **Chapter 6: Proposed Project - Engineering Features**.
f. **Public Transit Access:** Provide opportunity to safely accommodate and expand public transportation *	• **Opportunity to Accommodate:** Design provides opportunity to accommodate dedicated transit lanes. • **No Accommodation:** Design does not provide opportunity to accommodate dedicated transit lanes.	**Opportunity to Accommodate:** The Proposed Project includes provisions to accommodate dedicated 12-foot transit lanes in both directions for new transit services along the corridor. Discussion of potential public transportation opportunities is included in **Chapter 6: Proposed Project - Engineering Features**.
g. **Tourist Travel Times:** Reduce tourism travel time between North Side/East End and George Town	• **Large Beneficial:** Reduces peak direction travel time by more than 25%. • **Moderate Beneficial:** Reduces peak direction travel time by 15% to 25%. • **Slight Beneficial:** Reduces peak direction travel time by 5% to 14%. • **Neutral:** Reduces peak direction travel time by 0% to 4%.	**Large Beneficial:** The Proposed Project will reduce travel times by over 25% on average across all analysis years between the cruise port and various tourist destinations located in eastern, including Rum Point/Starfish Point, Queen Elizabeth II Royal Botanic Park, Mastic Trail, and Meagre Bay Pond. The Proposed Project is also expected to reduce travel times to/from the Owen Roberts Airport.

**These criteria are to provide opportunities to accommodate these features. It is outside the ambit of the NRA to provide utilities or public transportation.*

CSF Criteria	CSF Thresholds	Project Impacts
h. **Safety:** Improve safe vehicular travel by reducing roadway conflict points	• **Large Beneficial:** Consists of 100% new roadway with median barrier / multimodal facilities; new intersections consist of 100% roundabout or left-in/left-out access. • **Moderate Beneficial:** Consists of 75% to 99% new roadway with median barrier / multimodal facilities; new intersections consist of 75 to 99% roundabout or left-in/left-out access. • **Slight Beneficial:** Consists of 1% to 74% new roadway with median barrier / multimodal facilities; new intersections consist of 1 to 74% roundabout or left-in/left-out access. • **Neutral:** Provides no new roadway with median barrier / multimodal facilities; consists of no new roundabout or left-in/left-out intersections.	**Large Beneficial:** The Proposed Project improves safety by providing a new restricted access roadway facility that significantly reduces conflict points. The Proposed Project incorporates safety features including a median, separated pedestrian/bicycle facilities, roundabouts, and left-in/left-out access points across 100% of the new roadway. The Proposed Project is also projected to reduce intersection delay and overall traffic volume along the coastal roadway.
i. **Pedestrian & Bicycle Access:** Provide opportunity for enhanced and safe pedestrian and bicycle travel	• **Large Beneficial:** Consists of 100% pedestrian/bicycle facility connection between Woodland Drive and Frank Sound Road. • **Moderate Beneficial:** Consists of 75% to 99% pedestrian/bicycle facility connection between Woodland Drive and Frank Sound Road. • **Slight Beneficial:** Consists of 1% to 74% pedestrian/bicycle facility connection between Woodland Drive and Frank Sound Road. • **Neutral:** Provides no new bicycle facility connection between Woodland Drive and Frank Sound Road.	**Large Beneficial:** The Proposed Project will provide dedicated sidewalks and micromobility paths by 2036, providing full pedestrian/bicycle connectivity between Hirst Road and Frank Sound Road. These improvements will improve nonvehicular access to key destinations such as the Mastic Trail, Clifton Hunter High School, and Bodden Town Valu-Med pharmacy.

7.5 Mitigation Measures

Impacts from the Proposed Project are expected to degrade intersection delay at the intersections of Bodden Town Road at Frank Sound Road (#1100) in 2074, Frank Sound Road at Clifton Hunter High School (#1200) from 2036 onward, and EWA at Agricola Drive Connector (#1400) from 2046 onward (intersection locations shown in **Figure 7-28**). The Proposed Project negatively impacts these three intersections based on LOS criteria due to an increase in traffic demand and volumes. Improvements were added to mitigate these impacts, including traffic signals, additional turn lanes, and a multilane roundabout with bypass lanes. **Table 7-21** summarizes the improvements needed at each intersection for each future analysis year.

Table 7-21: Proposed Project Additional Improvements for Existing Intersections

#	Intersection	Improvement Needed	2026	2036	2046	2074
1100	**Bodden Town Rd at Frank Sound Rd**	Conversion to a traffic signal	No	No	No	Yes
1200	**Frank Sound Rd at Clifton Hunter HS**	Conversion to a traffic signal	No	Yes	Yes	Yes
		Restripe SB approach to include a SB right-turn lane	No	No	Yes	Yes
1400	**EWA at Agricola Drive Connector**	Conversion to three-lane roundabout with bypass lanes	No	No	Yes	Yes

Table Note: Refer to **Figure 7-28** for map of intersection locations.

Additional impacts for the Proposed Project are included in **Chapter 8: Socio-Economics**, **Chapter 9: Noise and Vibration**, and **Chapter 10: Greenhouse Gas Emissions,** since the traffic volume and speed data feed into these disciplines' mitigation considerations.

8 Socio-Economics

The study of socio-economics focuses on employment, income, and education, affecting how humans and communities live. As stated in the ToR, the objectives of this socio-economic assessment include evaluating the potential of the project to affect changes in these factors, along with "providing an understanding of the comprehensive and interrelated needs of individuals and the local communities."

This socio-economic chapter of the ES covers the following:

- Describes the methodology for socio-economics assessments;
- Establishes baseline socio-economic conditions within the study area;
- Identifies the potential benefits and adverse impacts due to the project, including construction and operation phases;
- Assesses the significance of these potential impacts; and
- Offers avoidance, minimisation, and mitigation considerations for the project's potential negative socio-economic impacts.

This chapter assesses the effects of the Proposed Project described in **Chapter 6: Proposed Project – Engineering Features**. Baseline Conditions, which equate to Existing Conditions, are established to demonstrate the socio-economic canvas of Grand Cayman. The Future No-Build conditions are consistent with **Chapter 7: Transportation and Mobility** and are used as a basis of comparison with the Proposed Project to characterize potential socio-economic impacts.

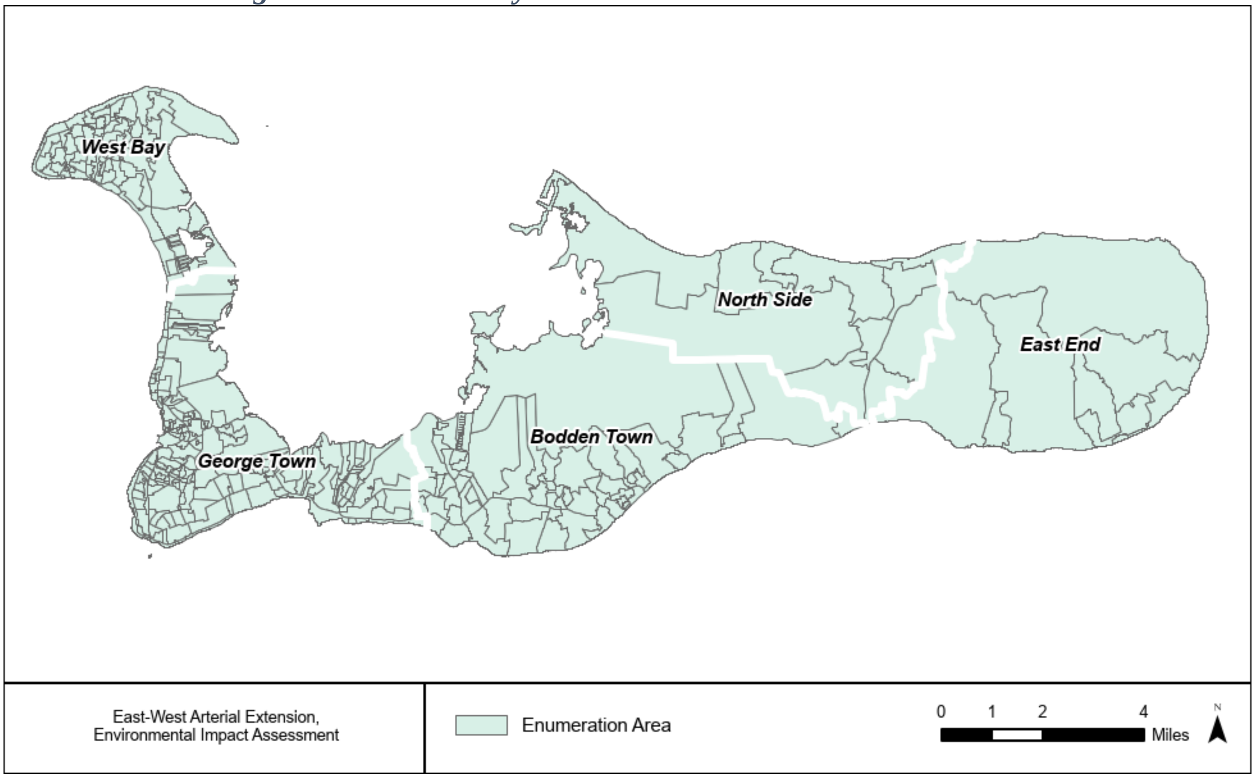
8.1 Assessment Methodology

This section describes the methodology used to assess socio-economic elements during the EIA process. This methodology comes from the ToR and follows established Cayman law and international standards and practices, which are described in the following subsections.

8.1.1 Study Area

The socio-economic study area includes all of Grand Cayman due to the island-wide effects that could result from a new east-west roadway on population, employment, businesses, and housing. Grand Cayman has five districts: George Town, West Bay, Bodden Town, North Side, and East End. Each district is comprised of Enumeration Areas (EA), which separate the five districts into smaller areas; they represent the smallest statistical units in census data and are comprised of approximately 100 households (**Figure 8-1**).

Figure 8-1: Grand Cayman Districts and Enumeration Areas



8.1.2 Components of Socio-Economic Evaluation

The ToR, which encompasses public comment and resulting revisions, lists socio-economic components and receptors for analysis to determine the potential benefits and impacts of the Proposed Project (**Table 8-1**). Socio-economic Baseline Conditions were evaluated to identify potential impacts of the Proposed Project and the level of possible changes to these components and receptors.

Table 8-1: Socio-Economic Components for Analysis

Component/Receptor	Definition and Scope
Aesthetics / "Quality of Life"	• The effect on traffic measures, such as travel time and LOS, compared to existing and future conditions; • The effect of the Proposed 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 the new roadway facility compared to existing and future impacts of sea-level rise under the No-Build scenario; • The potential for changes to the noise and visual environment for land uses located along the new roadway and connector roadways; • The effect of the Proposed Project on lifestyle/wellness associated with changes to commute times.

Component/Receptor	Definition and Scope
Access and Mobility	• The Proposed Project's effect on access needs along and adjacent to the project corridor based on an analysis of trip origination and destinations; • The Proposed Project's 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; • The potential for impacts on economic resiliency as a result of tourism change.
Income and Economics	• The potential for job creation during project construction and implementation; • The prioritisation of equitable business and employment opportunities; • Effects to tourism based on improved access.
Housing	• The potential for relocations necessary for project construction; • The potential for new development; • The potential for impacts to housing availability and affordability.

8.1.3 Applicable Standards and Guidelines

Relevant Cayman Islands laws, UK standards/guidelines, and CIG reports were reviewed to determine the methodology that was used to assess socio-economics. The assessed laws, standards, and reports included:

8.1.3.1 Cayman Laws and Standards

- Data Protection Act (2021 Revision)
  - The Cayman Islands Data Protection Act regulates how personal information can be processed and the right to privacy for residents for their personal information.
- Disaster Preparedness and Hazard Management Act (2019 Revision)
  - The Cayman Islands Disaster Preparedness and Hazard Management Act establishes a plan for preparing for, addressing, and responding to hazards, disasters, and emergency situations on the Islands.
- Disabilities (Solomon Webster) Law, 2016
  - The Cayman Islands Disabilities Law ensures that persons with disabilities receive the same legal protections and human rights as all persons and are able to participate fully in society.
- Education Act (Act 48 of 2016)
  - The Cayman Islands Education Act establishes standards, procedures, and requirements for the education system in the country and mandates that all persons aged between 5 and 17 are required to attend school.
- Employment Law (Act 3 of 2004) & Labour Act (2021 Revision)
  - The Cayman Islands Employment Law and the Cayman Islands Labour Act both establish standards for the conditions of employment on the Cayman Islands, such as terms of employment, period of employment, benefits provided, and other employee protection measures.

- Gender Equality Act (Act 21 of 2011)
  - The Cayman Islands Gender Equality Act ensures the fair and equitable treatment of all employees regardless of gender and that employment opportunities are available for all people regardless of their gender.
- Health Insurance Act (2021 Revision)
  - The Cayman Islands Health Insurance Act establishes a framework for health insurance coverage for Cayman Islands employees and establishes the requirements and obligations of employers in regard to the provision of health insurance coverage.
- Health Practice Act (2021 Revision)
  - The Cayman Islands Health Practice Act establishes the requirements for being a registered entity that provides health care services to residents.
- Health Services Authority Act (2018 Revision)
  - The Cayman Islands Health Services Authority Act established the Cayman Islands HSA and details the powers, duties, and responsibilities of the agency in their provision of health care services to residents.
- Labour Act (2021 Revision)
  - The Cayman Islands Labour Act establishes standards and conditions for employment, such as base salary requirements, leave conditions, and categories of employment.
- Land Acquisition Act (1997 Revision)
  - The Cayman Islands Land Acquisition Law establishes a process for government land acquisition and the fair compensation to those whose land was acquired.
- Older Persons Act (Act 14 of 2017)
  - The Cayman Islands Older Persons Act ensures that older persons are able to access the same resources and services as all other residents in the Cayman Islands and establishes a Council to ensure older persons have a voice in the legislation process.
- Poor Persons (Relief) Act (1997 Revision)
  - The Cayman Islands Poor Persons (Relief) Act establishes a framework for providing financial assistance and access to services to those who cannot financially afford it.
- Public Health Act (2021 Revision)
  - The Cayman Islands Public Health Act establishes a framework and standards for protecting the public health of the Cayman Islands population, such as the water supply quality, the handling of garbage, or the regulation of cemeteries, among others.
- Workmen’s Compensation Act (1996 Revision)
  - The Cayman Islands Workmen’s Compensation Act establishes a framework for the proper compensation of workers following any death or injury that occurs during their period of employment.

- Tourism Act (2002 Revision)
  - The Cayman Islands Tourism Act establishes the Department of Tourism and describes the rules, and procedures for how tourist activities should be regulated, as well as the promotion of tourism.
- Trade Union Act (2019 Revision)
  - The Cayman Islands Trade Union Act provides for the establishment of trade (labour) unions, which is an organization of workers to promote the betterment of work conditions in that sector.

8.1.3.2 Reports and Scholarly Publications

Reports from CIG agencies and international organisations include statistical information utilised for this socio-economic analysis. Those that informed this technical report include:

- *Cayman Islands' Census of Population and Housing 2021* – Cayman Islands ESO;
- *Cayman Islands' Compendium of Statistics (CoS) 2021* – ESO;
- *Cayman Islands' CoS 2022* – ESO;
- *The Cayman Islands' Gross Domestic Product (GDP) Report 2021* – ESO;
- *The Cayman Islands' Gross Domestic Product (GDP) Report 2022* – ESO;
- *The Cayman Islands' Annual Economic Report 2023* – ESO;
- *Data Report for the Academic Year 2021-22* – Department of Education Services;
- *National Road Safety Strategy 2023-2038* – NRA;
- *'Go East:' A Strategy for the Sustainable Development of the Eastern Districts of Grand Cayman 2009* – Ministry of Tourism, Environment, Investment and Commerce;
- *United Nations 2030 Agenda for Sustainable Development* – United Nations; and
- "Refining the attribution of significance in social impact assessment" – Rowan, M., in *Impact Assessment and Project Appraisal.*

8.1.3.3 UK Standards

UK Department for Transport's Transport Analysis Guidance (WebTAG):

- WebTAG unit A4-1 social impact appraisal; and
- WebTAG unit A4-2 distributional impact appraisal.

8.1.4 Data Sources Evaluated

8.1.4.1 Desktop Review

The Cayman Islands' 2021 Census of Population and Housing and the Cayman Islands' 2021 CoS were used to create a demographic profile and examine the social characteristics within the study area. These documents were developed by the ESO, and they provide information about population, demographic, social, and economic conditions. Additional 2021 data at the district and EA level was provided by the ESO.

The ESO released a 2022 CoS in late 2023; 2022 data is based on surveys rather than a larger decennial census count. Where available and applicable, the 2022 data is provided in this chapter alongside the 2021 census data to supplement additional context to the Baseline Conditions. However, since additional data received directly from the ESO came from the 2021 census, base population models developed for the traffic modelling efforts were developed using inputs from the 2021 census counts. Decennial census counts provide a more accurate representation of statistics for a geographic region; as a result, the 2021 census data is primarily relied upon when conducting socio-economic analyses for this chapter.

The Cayman Islands NRA, ESO, Lands & Survey Department, and Department of Education provided data and information for compiling Baseline Conditions and examining potential effects (**Table 8-2**). Secondary data sources included publicly available government information and data, news sources, non-governmental organization reports, and tourism materials.

Table 8-2: Socio-Economic Data and Sources

File Name	Description	File Type	Providing Agency	Date Provided
"Census 2021 – NRA Data Request"	2021 Census information by EA	Excel	ESO	7/18/2023
"ESO 2010 Census – NRA Data Request"	2010 Census information by EA	Excel	ESO	7/18/2023
"2019_Enumeration _Area"	2019 EA	Shapefile	ESO	7/18/2023
"2010_Enumeration _Area"	2010 EA	Shapefile	ESO	7/18/2023
"Shapefiles_for_Select _Data_Requested.zip"	Includes: • Cemeteries • Government Facilities • Civic Facilities • Schools	Shapefile	Lands & Survey Department	7/31/2023
"Government School Enrolment – 2022-23"	Enrolment numbers for government school facilities for the 2022-23 school year	Excel	Department of Education	7/31/2023
"Department of Education Staff – 2022-23"	Staff numbers and parcel information for schools in 2022-23	Excel	Department of Education	7/31/2023
"Preschool Locations and Number of Staff and Children"	Staff, enrolment, and parcel information for preschools	Excel	Department of Education	7/31/2023
"Private Schools_Enrolment and Staff numbers_22-23"	Private school enrolment data for 2022-23	Excel	Department of Education	8/3/2023
"Recreation_Areas"	Recreation areas and type of facility	Shapefile	NRA	9/18/2017
"PlanningZones"	Development Plan Zoning Designation Map	Shapefile	Lands & Survey Department	7/31/2023
"Buildings"	Buildings square footage data	Shapefile	Lands & Survey Department	7/31/2023

8.1.4.2 Stakeholder Consultation

On July 25, 2023, an EWA project-specific Land Use Planning Charrette took place with the purpose of identifying different population growth and land use scenarios that may occur on Grand Cayman in future year 2074. Details regarding the Land Use Planning Charrette can be found in **Section 3.5.2.1** and **Appendix C - Land Use Planning Charrette Summary Memorandum**.

8.1.4.3 Field Visit(s)

A field visit to gather Baseline Conditions data occurred from July 24 to 28, 2023. Socio-economic resources, including transit routes, public spaces, community facilities, and traffic conditions, were examined.

8.1.5 Description and Assessment of Impacts

Methodology for quantitative and qualitative assessment of impacts to socio-economic resources and conditions was described in the ToR and is based on the applicable standards and guidelines and the available data sources. The methodology encompasses the "Impact Prediction" components described in the NCC EIA Directive:

> a) *The sensitivity of the environmental resource;*
> b) *The magnitude of change;*
> c) *The likelihood of the impacts occurring;*
> d) *The certainty with which impacts have been identified;*
> e) *The comparison with the do nothing / future use of site; and*
> f) *The significance of the impacts based on factors (a) – (d) above*

The methodology was refined during the Alternatives Analysis phase of the EIA using WebTAG Unit A4-1 and A4-2. The socio-economic evaluation performed during the Alternatives Analysis focused on impacts associated with the operations phase of the EIA project. Additional refinements to the assessment methodology, including the incorporation of the construction phase, indirect and cumulative impacts, and mitigation measures, have been completed and are described in this ES.

Potential impacts and the level of possible change due to the construction and operation phases of the Proposed Project were identified by examining the effects on the Baseline Conditions and available data sources, as described in **Section 4.2.5 of the ToR**. The methodology expanded upon during the Shortlist Alternatives Evaluation (**Appendix E**), using WebTAG Units A4-1 and A4-2 for a **Social Impact Appraisal** (described more in **Section 8.1.6**), includes more detailed evaluation of these measures using a scaled assessment approach. As directed in WebTAG, the scaled approach was applied based on factors such as approximate number of people affected by the impact or average percent improvement or deterioration due to the impact, specific to each assessment subcategory.

As required by the EIA Directive, sensitivity and magnitude are necessary components of determining an environmental impact. WebTAG does not offer qualitative scaling for sensitivity or magnitude separately within the **Social Impact Appraisal;** however, the WebTAG analysis for

Social Impact Appraisal is designed to consider sensitivity and magnitude within the scaled approach (e.g., by considering the number of people affected or the percent improvement compared with the Future No-Build) when completing an evaluation. Therefore, during the impact analysis, magnitude and sensitivity as separate categories are not applicable because those categories are wrapped into the significance rating.

For construction and operation phase components and receptors not included in WebTAG's **Social Impact Appraisal**, the qualitative sensitivity and magnitude scaling described in *Refining the attribution of significance in social impact assessment* (Rowan, 2009) was applied. The scaling described in Rowan (2009) is as follows:

Sensitivity

- *High*: an already vulnerable receptor with very little capacity and means to absorb changes;
- *Medium*: a non-vulnerable receptor with limited capacity and means to absorb changes;
- *Low*: a non-vulnerable receptor with plentiful capacity and means to absorb changes.

Magnitude

- *Major:* a probable impact that either affects the wellbeing of groups of many people within a widespread area or continues beyond the project life and is effectively permanent, requiring considerable intervention to return to the socio-economic baseline;
- *Moderate:* a possible impact that will affect the wellbeing of a group of people beyond the site boundary into the local area, or continue beyond the project life so that the baseline is re-established with some intervention;
- *Minor:* a possible impact that will affect the well-being of a small number of people or which occurs exceptionally, mostly within the site boundary and does not extend beyond the life of the project, so that the socio-economic baseline returns naturally or with limited intervention within a few months.

In addition, mitigation strategies for the construction and operation phases of the Proposed Project were examined and described, as mentioned in **Section 4.2.6 of the ToR**.

8.1.6 Social Impact Appraisal

For this analysis, each social component described in WebTAG unit A4-1 was assessed to determine whether the Proposed Project could potentially result in an impact. Where a potential impact was projected, the data for that component was reviewed to determine the type of evaluation that was most appropriate. Additional economic effects (e.g., cost of construction, monetary value of improved travel time) were assessed as part of the Cost Benefit Analysis (CBA) prepared for this Proposed Project (see **Chapter 16: Cost Benefit Analysis** of this ES).

Based on the type of Proposed Project and the categories within WebTAG unit A4-1, with consideration of available data and relevance to the project, the following were determined to be the most applicable criteria for use via quantitative and qualitative evaluation:

- Accessibility
- Severance
- Journey Quality
- Option Values

The categories of Accidents, Physical Activity, Security, and Personal Affordability were not included in this evaluation due to insufficient data necessary to make an evaluation. For more information on the categories identified for evaluation of the Proposed Project, see **Appendix E - Shortlist [Alternatives] Evaluation Attachment C: Socio-Economic – Assessment of Alternatives**.

8.1.6.1 Accessibility Analysis

Per guidance from UK's WebTAG unit A4-1, accessibility impacts can be the physical access to public transport or the ability to get to goods and services (e.g., hospitals or education; **Section 8.2.4: Services**), as well as the ability to obtain information regarding public transport or other transportation related services. Accessibility impacts are a key consideration in the appraisal and assessment of transportation improvements as accessibility barriers can result in social exclusion. Overall, the Proposed Project is projected to improve travel to and from community facilities, jobs, and amenities, especially between the easternmost districts of Grand Cayman (North Side and East End), where these resources are relatively limited, and the westernmost districts of Grand Cayman (George Town and West Bay). As described in this chapter's **Section 8.2.2.3: District of Employment and Residence**, **Section 8.2.4.2: Emergency Services**, and **Section 8.2.4.3: Education**, employment opportunities, emergency services, and education opportunities are more plentiful in George Town than in any other district. The study of accessibility focuses on the populations in Bodden Town, North Side, and East End.

To qualitatively assess accessibility, the seven-point scale from WebTAG unit A4-2 was used to gauge the proportion of change in travel conditions for the Proposed Project when compared with the Future No-Build conditions (**Table 8-3**). The Accessibility Analysis Score corresponds with the "significance" category described in the EIA Directive.

Table 8-3: Accessibility Analysis Scale

Proportionate Changes	Accessibility Analysis Score
> +16%	Large Beneficial
+6% to +15%	Moderate Beneficial
+2% to +5%	Slight Beneficial
-1% to +1%	Neutral
-2% to -5%	Slight Adverse
-6% to -15%	Moderate Adverse
> -16%	Large Adverse

Source: WebTAG unit A4-2: Distributional Impact Appraisal, Table 15 p. 57

8.1.6.2 Severance Analysis

WebTAG unit A4-1 describes severance as the issue of transportation (infrastructure or traffic flows) affecting community members' abilities to reach the facilities and services they use within their communities. Severance can impact community cohesion, a concept relating to community identity. Community cohesion can be affected by splitting neighbourhoods, isolating a portion of a neighbourhood or an ethnic group, generating new development, changing property values, or separating residents from community facilities. WebTAG unit A4-1 notes that severance only becomes an issue if vehicle flows or infrastructure create a barrier to pedestrian movement, and not all transportation projects will result in negative impacts associated with severance. **Table 8-4** defines the four levels of severance as defined in WebTAG unit A4-1. While **Table 8-4** offers definitions of the four levels of the adverse effect of increased severance, a beneficial decrease in severance is also possible for projects that encourage non-vehicular movement when compared with the Future No-Build conditions.

Table 8-4: Four Levels of Severance Classification

Level	Description
None/Neutral	Little or no hindrance to pedestrian movement.
Slight Adverse	All people wishing to make pedestrian movements will be able to do so, but there will probably be some hindrance to movement.
Moderate Adverse	Pedestrian journeys will be longer or less attractive; some people are likely to be dissuaded from making some journeys on foot.
Large Adverse	People are likely to be deterred from making pedestrian journeys to an extent sufficient to induce a reorganisation of their activities. In some cases, this could lead to a change in the location of centres of activity or to a permanent loss of access to certain facilities for a particular community. Those who do make journeys on foot will experience considerable hindrance.

Source: WebTAG unit A4-1, Severance Impacts 5.1.3 p. 26

For this analysis, the overall assessment was based on the following guidelines (from WebTAG Unit A4-1 p. 27), with the assessment being **beneficial** if severance would be reduced, and **adverse** if severance would be increased:

- The overall assessment is likely to be **Neutral** if increases in severance are broadly balanced by relief of severance;
- The overall assessment is likely to be **Slight** where change in severance is slight or the total numbers of people affected across all levels of severance is low (less than 200 per day, say);
- The overall assessment is likely to be **Large** where change in severance is large, and affects a moderate or high number of people or the total numbers of people affected across all levels of severance is high (greater than 1,000, say); and
- The overall assessment is likely to be **Moderate** in all other cases.

Additionally, the degree of adverse or beneficial effect was considered alongside the number of people affected. For example, if a transportation change was likely to provide additional facilities for pedestrians but in an area where few pedestrian destinations are available, the significance of the benefit was adjusted accordingly.

8.1.6.3 Journey Quality Analysis Scale

Journey quality associated with transportation improvements is a measure of the real and perceived physical and social environment experienced while travelling. Poor journey quality may dissuade individuals from utilising a roadway facility. A qualitative assessment of factors influencing journey quality was completed as part of this **Social Impact Appraisal** for the Proposed Project. The assessment has been prepared following the approach identified in WebTAG unit A4-1, which recommends a qualitative appraisal of the following three groups of quality impacts and their sub-factors:

- **Traveller care**: aspects such as cleanliness, level of facilities, information, and the general transport environment;
- **Traveller views**: the view and pleasantness of the external surroundings in the duration of the journeys; and
- **Traveller stress**: frustration, fear of accidents, and route uncertainty.

This social impact appraisal utilises a qualitative approach to evaluating Journey Quality. The approach utilises population assessment guidelines described in WebTAG unit A4-1. This evaluation was modified to also consider the extent to which each sub-factor would affect potential travellers before making a final assessment. For example, by 2074, over 10,000 people are projected to benefit from the Proposed Project from a Journey Quality perspective, which would give the Proposed Project a "Large Beneficial" rating if the assessment were based solely on population. To differentiate between the Future No-Build and the Proposed Project, significance was also assessed based on the approximate extent each sub-factor would benefit travellers (i.e., how much of the new roadway is likely to be affected). The guideline in WebTAG unit A4-1 is as follows:

- The assessment is likely to be **neutral**, if the assessment is neutral for all or most of the sub-factors, or improvements on some sub-factors are generally balanced by deterioration on others;
- If the change in impact across the sub-factors is, on balance, for the better, the assessment is likely to be **beneficial**, and, conversely, it is likely to be **adverse** if there is an overall change for the worse;
- The assessment is likely to be **slight** (beneficial or adverse) where the numbers of travellers affected is low (less than 500 a day, say);
- The assessment is likely to be **large** (beneficial or adverse) where the numbers of travellers affected is high (more than 10,000, say); and
- The assessment is likely to be **moderate** (beneficial or adverse) in all other cases.

Consistent with WebTAG Unit A4-1, only sub-factors that have not been considered in other subsections of the Social Impact Appraisal are considered under Journey Quality. This analysis considers traveller views and traveller stress; traveller care primarily applies to public transport facilities, and the level of design detail necessary to apply the guidelines to road users was not available at this stage of analysis.

8.1.6.4 Option Value Analysis

Option values are defined by WebTAG unit A4-1 as the "willingness-to-pay to preserve the option of using a transport service for trips not yet anticipated or currently undertaken by other modes, over and above the projected value of any such future use." Option values are assessed when there is a change in the availability of a transportation facility or service in the study area, such as the introduction of a new roadway facility or local bus service. Values are assessed as beneficial when a service is introduced and as adverse when a service is removed. Consistent with WebTAG unit A4-1, the appraisal of impact on option and non-user values is focused primarily on the availability of public transport facilities or services to users and non-users within a study area or along a given route. The availability of these transport services offers users and non-users a variety of transportation options when reaching different parts of the island, including community facilities and recreation opportunities (e.g., tourists who dock in George Town receiving the option to reach sight-seeing opportunities on the east side of the island).

The Proposed Project would not include implementation of new public transport services; however, the Proposed Project includes the provision for transit lanes (dedicated transit lanes), a sidewalk, and micromobility path to accommodate future public transport and beneficial option values. See **Chapter 6: Proposed Project - Engineering Features** for descriptions of these elements.

To assess the anticipated option value benefits associated with the Proposed Project, an evaluation of bicycle journeys and LTS was conducted in comparison to the Future No-Build conditions. LTS is a performance measure that ranks a roadway facility's suitability for bicycle, pedestrian, and other micromobility access. Facilities are ranked on a scale of 1 to 4, with 1 being the most suitable for a variety of bicyclists or micromobility users, ages, and abilities and 4 being the least suitable (**Table 8-5**). LTS offers information on modes of transport other than vehicular that would become a user and non-user option under the Proposed Project. For a more in-depth discussion of LTS and non-vehicular access, see **Chapter 7: Transportation and Mobility**.

Table 8-5: Bicycle Levels of Traffic Stress Definitions

LTS 1	Suitable for children – there is physical separation from traffic or mixing with traffic on low speed, low volume roadways
LTS 2	Suitable for the average adult – there is physical separation from high speed and multilane traffic or mixing with traffic on low, but higher than LTS 1, speed and volume roadways
LTS 3	Suitable for "enthusiastic and confident" riders – there is mixing with traffic on moderate speed, multilane traffic or mixing with high-speed traffic with some separation
LTS 4	Suitable only for "strong and fearless" riders – there is mixing with high-speed traffic with little separation

Source: Furth & Putta (2016), "Visualizing and Measuring Low-Stress Bicycle Network Connectivity in Delaware"

The assessed number of households in East End, North Side, and Bodden Town for which the transportation intervention could potentially change the availability of transport services, including walking, biking, and other, helped inform the magnitude of impact of the option value. The option values are connected with the appraisal of accessibility (**Section 8.1.6.1**) and with severance impacts (**Section 8.1.6.2**), because these evaluations focused on the convenience of the facility and number of people potentially affected by the Proposed Project.

The following qualitative assessment criteria was used to help inform the magnitude of option value impacts, consistent with WebTAG unit A4-1 for social impact appraisals:

- Large impact (beneficial or adverse): ≥1,000 households;
- Moderate impact (beneficial or adverse): 250-999 households;
- Slight impact (beneficial or adverse): 1-249 households; and
- Neutral impact (beneficial or adverse): 0 households.

8.2 Baseline Conditions

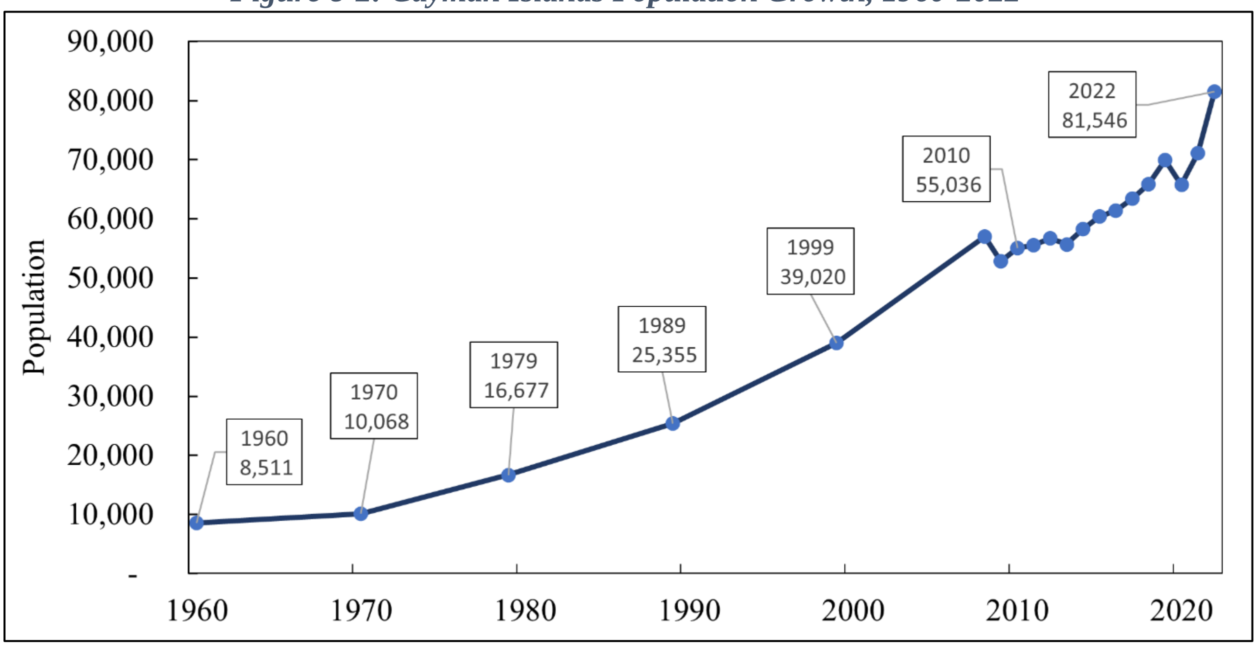
Baseline Conditions establish an understanding of socio-economic components and receptors. The Baseline Conditions described in this chapter relate directly to the impacts analysed in **Section 8.3.** Additional Baseline Conditions can be found in **Appendix E - Shortlist [Alternatives] Evaluation Attachment C: Socio-Economic – Assessment of Alternatives.**

8.2.1 Demographics

8.2.1.1 Population and Housing

The population on the Cayman Islands has grown substantially since the 1960s. In 1960, the population for the Cayman Islands was under 10,000. By 2021, the ESO reported the population at 71,105 (68,848 on Grand Cayman), and by 2022, the ESO reported a Cayman Islands population of 81,546 (79,241 on Grand Cayman [**Figure 8-2**]).

Figure 8-2: Cayman Islands Population Growth, 1960-2022



The period from 1989 through 2021 has been one of considerable population growth. The population of the Cayman Islands grew by more than 50% between 1989 and 1999, by over 40% between 1999 and 2010, and by almost 30% between 2010 and 2021. Bodden Town has been the fastest growing district through the last three decades. Cayman Islands population growth during this timeframe is summarized in **Table 8-6**, and for Grand Cayman is broken down by district.

Table 8-6: Cayman Islands Population Percentage Growth 1989-2021

	1989-1999		1999-2010		2010-2021	
	% Growth	Annual % Growth	% Growth	Annual % Growth	% Growth	Annual % Growth
Cayman Islands	53.9	4.4	41.0	3.2	29.2	2.4
George Town	59.6	4.8	36.2	2.8	24.3	2.0
West Bay	46.4	3.9	36.1	2.8	36.6	2.9
Bodden Town	69.2	5.4	82.9	5.6	40.8	3.2
North Side	28.9	2.6	2.6	0.2	35.2	2.8
East End	25.9	2.3	37.1	2.9	24.8	2.0

Source: CoS (2021) Table 1.10 (p. 22)

Housing demand has also substantially grown with the increasing population. In the last decade, Grand Cayman went from 24,415 households in 2016 to 32,820 households in 2022 (**Table 8-7**). George Town was the district with the most households (15,331 in 2021 and 18,003 in 2022). In 2021, East End was the district with the fewest houses (696); however, in 2022 North Side had the fewest houses (774).

Table 8-7: Cayman Islands Total Households, 2016-2022

	2016	2017	2018	2019	2020	2021	2022
Cayman Islands	25,561	25,197	27,925	28,834	27,084	29,699	34,133
Grand Cayman	**24,415**	**24,131**	**27,053**	**27,667**	**26,197**	**28,639**	**32,820**
George Town	*13,591*	*13,497*	*14,534*	*16,136*	*15,359*	*15,331*	*18,003*
West Bay	*4,986*	*4,913*	*6,012*	*5,531*	*5,052*	*6,408*	*7,012*
Bodden Town	*4,485*	*4,466*	*4,866*	*4,945*	*4,866*	*5,478*	*6,166*
North Side	*708*	*644*	*942*	*545*	*491*	*726*	*774*
East End	*645*	*611*	*699*	*510*	*428*	*696*	*866*

Source: CoS (2021) Table 1.14

8.2.1.2 Vulnerable Populations

To consider transportation-related impacts, vulnerable populations on Grand Cayman likely to benefit from improved access due to the Proposed Project were identified. **Table 8-8** highlights the characteristics of these vulnerable groups. This analysis includes a focus on the higher proportion of vulnerable persons within the populations of North Side and East End, to ensure that the benefits of the Proposed Project would be equally shared by these vulnerable and underserved populations while avoiding any disproportionate adverse effects.

Table 8-8: Vulnerable Groups per District for Grand Cayman (2021 census)

	George Town	West Bay	Bodden Town	North Side	East End
Population	34,921	15,335	14,845	1,902	1,846
Households	15,331	6,408	5,478	726	696
Households with children	3,480	1,545	1,767	212	154
Households without automobile	11,851	4,863	3,711	143	211
Children 14 and under	5,106	1,503	2,671	335	268
Persons age 65+	2,225	1,326	1,146	208	206
Persons commuting to work by walking	757	168	89	22	168
Persons earning less than CI$14,399	1,745	828	702	110	125
Households receiving subsidised rent	48	32	13	19	8
Households receiving financial assistance from Needs Assessment Unit (NAU)	808	759	511	130	159
Households (Able-bodied) receiving financial assistance	43	39	33	9	6
Households (Disabled) receiving financial assistance	138	126	68	16	24
Households (Elderly) receiving financial assistance	563	530	326	91	117
Households (Families) receiving financial assistance	64	64	84	14	12

Source: ESO

8.2.2 Employment

In 2021, 44,441 persons were employed in the Cayman Islands, compared with a working age population of 57,360 persons and a labour force of 47,120 persons. In 2022, an estimated 56,355 persons were employed, a 27% increase from 2021. From 2015 to 2022, the working age population grew by almost 41%, the labour force grew by 41%, and the number of employed persons grew by 44%. More than 500 additional people were unemployed in 2020 than in 2019, a change from 3.5% to 5.2% unemployment rate. From 2020 to 2021, unemployment rose from 5.2% to 5.7%, an addition of 400 unemployed people. However, in 2022 unemployment fell to 2.1%, cutting the number of unemployed persons by more than half.

8.2.2.1 Employment Characteristics by District

According to the ESO's 2021 Census of Population and Housing, George Town is the district with the highest labour force participation rate (85.0%) and the lowest unemployment rate (4.4%). North Side and East End have the smallest labour forces (1,146 persons and 1,131 persons, respectively) but the highest unemployment percentages (8.7% and 8.1%, respectively, see **Table 8-9**).

Table 8-9: Employment Characteristics by District, 2021

District	Working Age Population	Labour Force	Employed	Unemployed	Participation Rate (%)	Unemployment Rate (%)
George Town	28,513	24,232	23,170	1,062	85.0	4.4
West Bay	12,430	9,834	9,081	753	79.1	7.7
Bodden Town	11,648	9,418	8,792	625	80.9	6.6
North Side	1,523	1,146	1,047	100	75.2	8.7
East End	1,463	1,131	1,039	92	77.3	8.1

Source: Census of Population and Housing (2021), Table 9.3A

8.2.2.2 District of Employment and Residence

As the most populated district, George Town is also the district offering the most employment opportunities. **Table 8-10** represents a comparison of the district in which people work versus the district in which they live. 13,640 people who work in George Town live in one of the other four districts. In total, 7,212 people who work in George Town live in Bodden Town, North Side, or East End. More people who live in West Bay, Bodden Town, and North Side work in George Town than work in their respective districts of residence.

Table 8-10: Employment by District of Residence vs. District of Employment, 2021

		District of Residence									
		George Town		West Bay		Bodden Town		North Side		East End	
District of Employment	**George Town**	19,021	58.3%	6,410	19.6%	6,239	19.1%	568	1.8%	405	1.2%
	West Bay	2,393	46.5%	2,274	44.3%	424	8.3%	24	0.5%	20	0.4%
	Bodden Town	774	28.1%	200	7.3%	1,638	59.5%	69	2.4%	77	2.7%
	North Side	107	20.2%	23	4.4%	115	21.7%	256	48.4%	28	5.3%
	East End	165	17.9%	18	1.9%	167	18.1%	103	11.2%	470	50.9%

Source: Data provided by ESO

8.2.2.3 Modes of Transportation

Most workers on Grand Cayman use a private vehicle to commute to work (37,624 or 84.5%; **Table 8-11**). Over 80% of the working population in each district uses a private vehicle to get to work in each district, other than East End, where 70.9% of workers (773 people) use a private vehicle to commute. The public bus is the next most common way of commuting to work; a total of 2,884 workers on Grand Cayman (6.5%) use the bus to commute. In East End, 15.4% of the district's working population walks to work (168 people). That is also the same number of people who reportedly walk to work in West Bay, but given West Bay's higher population, it represents 1.8% of West Bay's working population. For information regarding the number of households with and without an automobile, see **Appendix E - Shortlist [Alternatives] Evaluation Attachment C: Socio-Economic – Assessment of Alternatives**.

Table 8-11: Mode of Commute by District 2021 (by Persons)

District	Total	Private Vehicle		Public Bus		Walking		Work from Home		Other+	
		No.	%	No.	%	No.	%	No.	%	No.	%
George Town	23,869	20,036	83.9%	1,450	6.1%	757	3.2%	507	2.1%	1,119	4.7%
West Bay	9,419	7,960	84.5%	765	8.1%	168	1.8%	306	3.3%	220	2.3%
Bodden Town	9,065	7,941	87.6%	518	5.7%	89	1.0%	340	3.8%	176	1.9%
North Side	1,072	914	85.3%	82	7.7%	22	2.1%	40	3.7%	13	1.2%
East End	1,091	773	70.9%	69	6.3%	168	15.4%	45	4.1%	36	3.3%
Total	44,516	37,624	84.5%	2,884	6.5%	1,204	2.7%	1,238	2.8%	1,564	3.5%

Source: Data provided by ESO
+Other includes bicycle, boating, taxi, motorcycle/moped, and Don't Know/Not Stated (DK/NS)

8.2.3 Economic Characteristics

8.2.3.1 Major Industries

According to the ESO's 2021 GDP Report, the financial and insurance services industry was the highest contributor to Cayman Islands GDP from 2017 to 2021. Other industries with high contributions to GDP include professional, scientific, and technical activities; real estate activities; wholesale and retail trade; and public administration and defence (**Table 8-12**). Tourism and its dependent industries are a major contributor to the GDP of the Cayman Islands. Before the COVID-19 pandemic, the Cayman Islands had more than one million visitors each year. In the ESO's *The Cayman Islands' Annual Economic Report 2023*, the ESO reported 1.7 million visitor arrivals to the island (including stay-over and cruise arrivals), indicating recovery from low tourism numbers in 2020 and 2021 due to the COVID-19 pandemic.

Table 8-12: Top 5 Industries Contributing to Cayman Islands GDP+

Industry	2019	2020	2021	2022
Financial & Insurance Services	1,378,451.7	1,391,018.6	1,404,656.3	1,480,247.1
Professional, Scientific & Technical Activities	583,695.6	618,941.9	651,523.2	659,919.3
Real Estate Activities	378,847.0	368,440.3	368,810.9	375,546.2
Wholesale & Retail Trade	291,691.7	286,515.1	293,164.8	307,289.5
Public Administration & Defence	237,996.9	246,961.7	260,513.4	276,341.7

Source: GDP Report (2021) Table 2, GDP Report (2022) Table 2
+GDP at constant basic & purchasers' prices, 2015=100 (CI$'000)

In 2021, the industries that employed the most people were construction; wholesale and retail; and professional, scientific, and technical activities. **Table 8-13** illustrates the major industries in 2019, 2020, and 2021 by the number of people employed in each industry.

Table 8-13: Major Industries and Employment in the Cayman Islands

Industry	2019	2020	2021	2022
Construction	5,368	5,074	6,324	8,827
Wholesale and Retail	5,365	4,935	5,103	7,201
Professional, Scientific and Technical activities	4,715	3,706	4,667	5,200
Financial Services	3,502	3,659	3,654	4,024
General Public Administration Activities	3,191	3,287	3,100	3,262
Administrative and Support Service Activities	2,715	2,645	2,895	4,135
Activities of households as employers	4,042	2,883	2,886	4,087
Restaurants and Mobile Food Services Activities	2,747	1,916	2,528	2,498
Human Health and Social Work Activities	2,218	1,915	2,368	2,835
Education	2,351	1,898	2,053	2,420
Transportation and Storage	1,945	1,438	1,589	3,144
Accommodation	3,131	1,913	1,486	1,779
Other Service Activities	836	1,262	1,200	1,691
Information and Communication	868	679	825	902
Manufacturing, Mining and Quarrying	846	924	823	750
Arts, Entertainment and Recreation	1,115	753	788	949
Real Estate	705	892	705	885
DK/NS	713	1,087	567	941
Electricity, Gas, Steam and Air Conditioning Supply, Water Supply and Sewerage	455	335	548	516
Agriculture and Fishing	567	419	326	306
Extra-territorial organizations	-	24	8	-
Total	***47,395***	***41,644***	***44,441***	***56,355***

Source: CoS (2021), Table 10.04 (p. 100)

Financial and Insurance Services

In 2021, the financial and insurance services industry contributed more than a quarter of the Cayman Islands' total GDP, per the 2021 GDP Report. According to the Ministry of Financial Services, the government has been enacting financial services legislation since the 1960s, making the Islands a business-friendly environment and allowing the financial sector to grow as a significant portion of Cayman Islands GDP.

Tourism

The tourism industry in the Cayman Islands experienced a downturn during the COVID-19 pandemic. In 2019, before the pandemic, the Real GDP of hotels and restaurants (tourism-dependent industries) was CI$251 million, according to the ESO's GDP Report of 2021. The same report details that the hotels and restaurants industry's Real GDP fell to CI$122 million in 2020 and contracted a further 13.6% in 2021; one of the main factors in the 2021 contraction was the reduction in overnight visitors. The 2022 GDP report states that of service-producing industries, the hotels and restaurants industry had the largest growth in 2022 of 59.6%, demonstrating significant recovery in the tourism industry, fuelled in part by 2022's increase in overnight visitors (284.3 thousand).

According to the ESO, no cruise ship visitors arrived in 2021, and air arrivals contracted 85.8%. ESO data shows that tourism numbers began to climb again in 2022. For 2023, 1.7 million visitors (via air and ship) were reported.

From a tourism perspective, Bodden Town, East End, and North Side are rich in cultural and ecological value but have remained less known to visitors, according to the “Go East” report prepared in 2009 by The Tourism Company for the Cayman Islands Department of Tourism. George Town and West Bay, in contrast, represent the core of the Cayman Islands tourism industry, with many attractions: the airport, seaport, major hotels, and established restaurants located in these areas. In addition, the Sister Islands, renowned for their tranquillity, diving, nature, and culture, have long had a distinct voice in tourism promotions. As for other attraction areas, outside of Rum Point and Cayman Kai, and to a lesser extent, various timeshare properties along the North Coast, Bodden Town, East End, and North Side have not had a coherent tourism model. The consequences of having less tourism in these districts results in fewer economic advantages for the residents there. These districts complement the breadth of experiences available in Grand Cayman with much Caymanian architecture, natural environment, and culture remaining intact and highly visible in these areas (The Tourism Company, 2009).

8.2.4 Services

8.2.4.1 Transportation Services

Transportation services on Grand Cayman include public transportation, air travel, and port access.

- **Public Transportation** - In accordance with the Traffic Law of 2011, the Public Transport Unit governs and oversees the public transportation network in the Cayman Islands;
- **Airport** - The Owen Roberts International Airport, the only public airport located on Grand Cayman, is located at 210 Roberts Dr, George Town, Cayman Islands. Based on the Cayman Islands Airports Authority 2021 Statistics, Owen Roberts International Airport transported over 177,886 passengers; 568,041 kilograms of freight; and 5,644 kilograms of mail in 2021.
- **Cayman Port** - The Port of George Town is operated by the Port Authority of the Cayman Islands. The Port of George Town handles both cargo and passenger service on Grand Cayman. For additional information regarding cargo and cruise ship passenger assumptions in connection with the traffic evaluation, reference **Appendix E - Shortlist [Alternatives] Evaluation: Attachment A – Traffic [Transportation & Mobility] – Assessment of Alternatives**.

8.2.4.2 Emergency Services

The CIG provides emergency services to Cayman Islands residents in the form of medical, police, fire, and hurricane shelters. The services available on Grand Cayman include:

- **Police** - Along with administrative facilities, Grand Cayman has five police stations, one in each district;
- **Fire** - There are currently three stations in Grand Cayman, located in West Bay, George Town, and on Frank Sound Road;

- **Medical** - Grand Cayman's main hospital is George Town Hospital, part of the HSA. While George Town Hospital is the only authorized provider of 24-hour Accident & Emergency services, other hospital services and district clinics are available on Grand Cayman; and,
- **Hurricane Shelters** - As of 2022, there are 14 hurricane shelters on Grand Cayman. Depending on the severity of the threat and other factors, Hazard Management Cayman Islands will decide how many shelters to open.

8.2.4.3 Education

In the Cayman Islands, children between the ages of 5 and 17 must attend compulsory education. During the 2022-23 school year, 5,308 students were enrolled in public school (including the Cayman Islands Further Education Centre), and a total of 4,776 students were enrolled in private school, according to information received from the Department of Education. The Cayman Islands has 12 public primary schools (11 on Grand Cayman and 1 on Little Cayman) and 3 public secondary schools (all on Grand Cayman). Grand Cayman houses one school encompassing all grades (Lighthouse School), a Further Education Centre, and 19 private primary and secondary schools.

According to the 2022 data report by the Department of Education George Town houses 15 of the island's 23 primary and secondary schools. In the 2021-2022 school year, 6,404 primary- and secondary-age children (74%) went to school in George Town. Of the households with children on Grand Cayman, close to 49% live in George Town. Almost 30% of all households with children live east of George Town, and over 5% of households with children live in East End or North Side.

8.2.5 Zoning for Land Use

Cayman's Development and Planning Law establishes a Central Planning Authority for Grand Cayman. This body reviews planning permission applications, required for land development or change of zoning, and authorises enforcement. The 1997 Development Plan designates the following categories and subcategories of development planning zones:

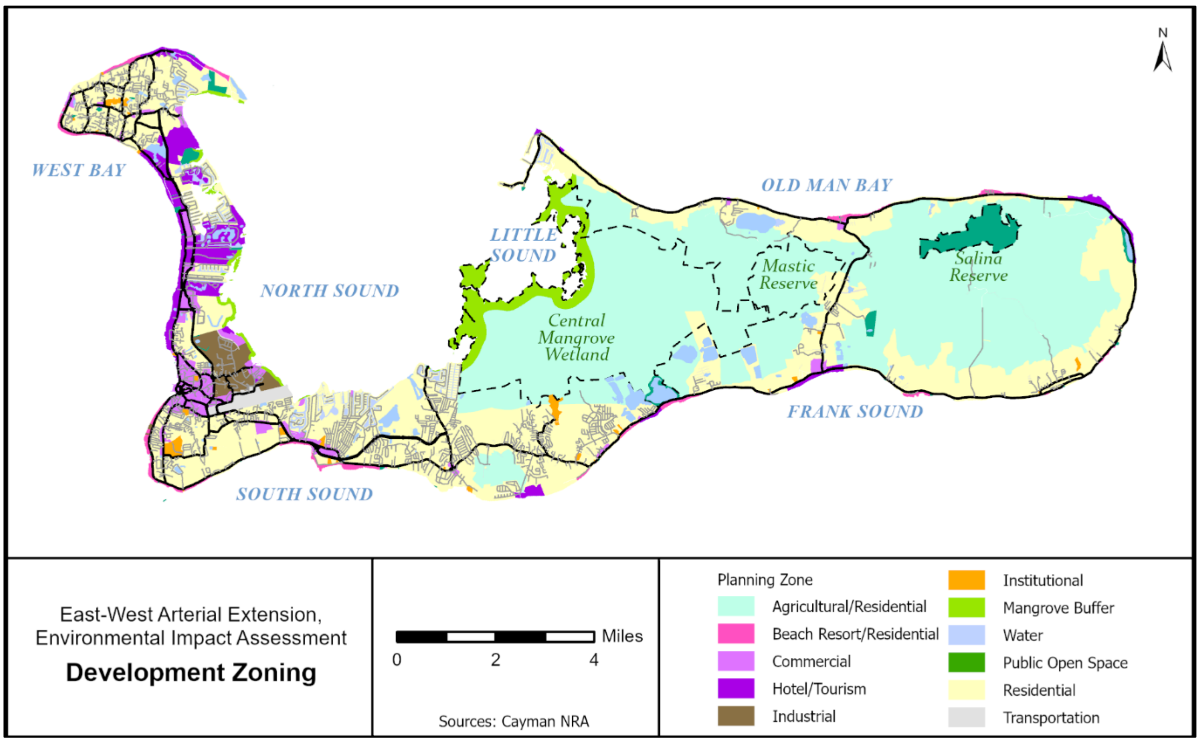
- Agricultural/Residential
- Residential
    - Low Density
    - Medium Density
    - High Density
- Beach Resort/Residential
- Hotel/Tourism
- Commercial
    - General Commercial
    - Neighbourhood Commercial
    - Marine Commercial
- Industrial
    - Light Industrial
    - Heavy Industrial
- Institutional

- Mangrove Buffer
- Public Open Space
- Historic Overlay
- Scenic Coastline

Figure 8-3 depicts the zoning information for Grand Cayman as of 2022 per the Planning Department's Development Plan. Subcategories of residential, commercial, and industrial were aggregated into their respective main categories. West Bay and George Town have the most Commercial and Hotel/Tourism planning zones. George Town contains the only lands with the Industrial zoning designation. Bodden Town is primarily Residential zoning. North Side and East End are primarily zoned for Agricultural/Residential with some Low Density Residential.

A Draft Cayman Islands Development Plan Planning Statement document was released in March 2024. Until specific area plans are developed, and a final planning document released, the 1997 Zoning map remains in effect.

Figure 8-3: Zoning for Grand Cayman



8.2.6 Baseline Summary and Key Findings

These Baseline Conditions have been compiled and utilised to supplement a variety of disciplines throughout the analysis, including **Transportation and Mobility** and **Engineering**. Information about the social and economic characteristics of Grand Cayman allow for appraisal of the social impacts of the Proposed Project, which is described in the following section.

8.2.6.1 Key Findings – Demographics

The population of the Cayman Islands has more than doubled since 1989, with most of the population living on Grand Cayman. The islands experienced 4.4% average annual growth between 1989 and 1999, 3.2% average annual growth between 1999 and 2010, and 2.4% average annual growth between 2010 and 2021. The population of George Town remains the largest of the five Grand Cayman districts. Bodden Town has grown the fastest, and now has roughly the same number of people as West Bay.

8.2.6.2 Key Findings – Employment

George Town provides the most jobs of any Grand Cayman district. Many people from West Bay, Bodden Town, North Side, and East End rely on commuting to George Town for employment opportunities. North Side and East End have the highest unemployment rates compared to other districts (over 8% while the rest are under 8%). Most people rely on a private vehicle to commute to work.

8.2.6.3 Key Findings – Economic Characteristics

Financial and insurance services is the top industry in the Cayman Islands in terms of GDP contribution. In 2021, the industry employing the most people was construction. Tourism is a contributor to multiple industries on Grand Cayman, however, the limited advertisement for tourism destinations in Bodden Town, North Side, and East End combined with the difficulty of day-trippers reaching these districts means that most tourism occurs in George Town and West Bay.

8.2.6.4 Key Findings – Services

The port and the airport are both located in George Town. The port location makes cruise passenger trips to Bodden Town, North Side, and East End more difficult, and the airport location means longer travel times for residents of these eastern districts. Police and fire stations are distributed across the island. The only A&E hospital authorized by HSA is in George Town, though a private hospital is available in East End and Grand Cayman has additional healthcare resources. Public schools are available in each district, but the majority of private schools are situated in George Town. George Town is also home to two of Grand Cayman’s three public high schools.

8.3 Project Impacts

This section describes the potential impacts to socio-economics that are estimated to occur as a result of the Proposed Project. The Future No-Build condition is also included as a basis for comparison to demonstrate the impacts and benefits of the Proposed Project. The Proposed Project is described in **Chapter 6: Proposed Project - Engineering Features** and traffic evaluations **in Chapter 7: Transportation and Mobility**. **Chapter 15: Summary of Direct, Indirect, Secondary/Induced and Cumulative Effects** includes Secondary, Induced, and Cumulative impacts.

Due to the phasing of the construction timeline, the future years 2026, 2036, 2046 and three growth scenarios for 2074 (projected low, medium, and high population/development growth) were analysed for this discipline where appropriate.

8.3.1 Social Impact Appraisal

This subsection evaluates the accessibility, severance, journey quality, and option values of the Proposed Project. The Future No-Build is used as a basis of comparison, where necessary, e.g., to demonstrate a travel-time benefit.

8.3.1.1 Accessibility

According to the data collected, many people in the three eastern districts depend on opportunities in the two western districts for employment (**Section 8.2.2**: **Employment**). The two western districts have a higher percentage of people (per district population) that fall into the highest income bracket when compared with the three eastern districts (for income distribution information see **Appendix E – Shortlist [Alternatives] Evaluation Attachment C: Socio-Economic – Assessment of Alternatives**).

To consider accessibility impacts, both a quantitative and a qualitative approach were used for this evaluation. This evaluation focuses on determining the effects of improvements to travel on people's access to services primarily located on the western side of Grand Cayman (e.g., employment and education). The level of access was determined based on where people live, where services and opportunities are located, and whether journeys between these origins are "appropriate in terms of time and cost" (WebTAG unit A4-1 p. 41). The Future No-Build represents the "without scheme" scenario described in WebTAG unit A4-1. The Future No-Build is the basis of comparison for the Proposed Project.

In addition, vulnerable groups who could benefit most from accessibility improvements were identified (**Section 8.2.1.2: Vulnerable Populations**), and members of these groups in Bodden Town, North Side, and East End are highlighted for reference in **Table 8-14**.

Table 8-14: Vulnerable Groups Within the Eastern Districts (2021 census)

	Bodden Town	North Side	East End
Population	14,845	1,902	1,846
Households	5,478	726	696
Households with children	1,767	212	154
Households without automobile	3,711	143	211
Children 14 and under	2,671	335	268
Persons age 65+	1,146	208	206
Persons commuting to work by walking	89	22	168
Persons earning less than CI$14,399	702	110	125
Households receiving financial assistance from NAU	511	130	159
Households (Able-bodied) receiving financial assistance	33	*9*	*6*
Households (Disabled) receiving financial assistance	68	*16*	*24*
Households (Elderly) receiving financial assistance	326	*91*	*117*
Households (Families) receiving financial assistance	84	*14*	*12*

Source: 2021 CoS

Travel time

Vehicle travel times were assessed between North Side/East End/East Bodden Town and George Town. Travel times were averaged between AM westbound movement and PM eastbound movement to evaluate access improvements for the eastern districts during peak travel times for both the opening year (2026) and the horizon year (2074). The projected Grand Cayman population for 2026 is 76,373, and the projected population for the 2074 "core" scenario is 135,000. See the GCM in **Chapter 7: Transportation and Mobility** for more information. A representative number of destinations in each district were selected to provide a summary of the anticipated accessibility impacts associated with the Proposed Project. To address accessibility questions surrounding emergency services, education, and other opportunities such as travel and tourism, representative destinations in the western districts were chosen to be George Town Hospital, Walkers Road Schools, and Owen Roberts Airport.

Changes in travel times were compared with the Future No-Build conditions to calculate the percent change per origin/destination combination for the Proposed Project. A positive number indicates a percent improvement, and a negative number indicates a percent deterioration. As shown in **Table 8-15**, the Proposed Project is expected to provide a notable improvement in travel times; and improved travel time compared to the Future No-Build scenario is expected to provide expanded regional access for residents who commute to places of employment and economic opportunities (**Section 8.2.2.3: Modes of Transportation**). Additionally, the Proposed Project is expected to improve traffic flow across Grand Cayman to benefit access to emergency services, education, and community facilities.

As shown in **Table 8-15**, in 2026, the Proposed Project is anticipated to offer a 9% improvement in travel times, which corresponds to a "Moderate Beneficial" significance on WebTAG's accessibility analysis scale. In 2074, the Proposed Project is anticipated to offer a 17% improvement in travel times, which corresponds to a "Large Beneficial" significance on WebTAG's accessibility analysis scale.

Table 8-15: North Side/East End AM/PM Average Travel Times 2026 and 2074

Origin / Destination	Future No-Build	Proposed Project
2026 AM and PM average travel time (minutes)		
North Side / George Town Hospital	54	47
North Side / Walkers Road Schools	49	42
North Side / Owen Roberts Airport	53	47
East End / George Town Hospital	56	52
East End / Walkers Road Schools	50	47
East End / Owen Roberts Airport	55	51
East Bodden Town / George Town Hospital	41	38
East Bodden Town / Walkers Road Schools	35	32
East Bodden Town / Owen Roberts Airport	39	36
Average Travel Time East / West	48.5	44.1
% Reduction from Future No-Build	**-**	**-9%**
2074 AM and PM average travel time (minutes)		
North Side / George Town Hospital	83	61
North Side / Walkers Road Schools	85	66
North Side / Owen Roberts Airport	81	60
East End / George Town Hospital	75	64
East End / Walkers Road Schools	79	72
East End / Owen Roberts Airport	75	65
East Bodden Town / George Town Hospital	56	49
East Bodden Town / Walkers Road Schools	59	55
East Bodden Town / Owen Roberts Airport	56	49
Average Travel Time East / West	72.9	60.7
% Reduction from Future No-Build	**-**	**-17%**

Source: GCM

Tourist accessibility to destinations is important to the Cayman economy. Many tourists arrive on Grand Cayman by cruise, meaning they have limited time during the day to visit tourist destinations. Travel times between the cruise port (located in George Town) and tourist attractions in eastern districts can make visiting these sites difficult or impossible. **Table 8-16** shows the travel time improvements projected for the Proposed Project in 2026 and 2074. While some destinations would remain unlikely for daytime tourists, especially in 2074 (Rum Point & Starfish Point), other destinations (the Mastic Trail and the Botanic Park) may become feasible options.

The Proposed Project is anticipated to offer an 11% improvement in tourist travel times for 2026, which is associated with a "Moderate Beneficial" significance on WebTAG's Accessibility analysis scale. For the 2074 "core" scenario, the Proposed Project is anticipated to offer a 19% improvement, which corresponds to a "Large Beneficial" significance.

Table 8-16: Tourist Travel Times to/from Cruise Port, 2026 and 2074

Origin/Destination	Future No-Build	Proposed Project
2026 AM and PM average travel time (minutes)		
Cruise Port / Rum Point & Starfish Point	51	46
Cruise Port / Bodden Town Mission House	24	23
Cruise Port / Botanic Park	35	30
Cruise Port / Mastic Trail	36	29
Cruise Port / Meagre Bay Pond	27	24
Average Travel Time Cruise Port / Destination	34	30
% Reduction from Future No-Build	-	**-11%**
2074 AM and PM average travel time (minutes)		
Cruise Port / Rum Point & Starfish Point	90	75
Cruise Port / Bodden Town Mission House	48	42
Cruise Port / Botanic Park	67	50
Cruise Port / Mastic Trail	75	59
Cruise Port / Meagre Bay Pond	52	45
Average Travel Time Cruise Port / Destination	67	54
% Reduction from Future No-Build	-	**-19%**

Source: Grand Cayman Travel Demand Model

Trip numbers

The capacity of the proposed new roadway facility was also assessed to determine the additional trips that would be accommodated between North Side and East End and western districts as a result of access improvements from the Proposed Project. Improved access to and from the western side of the island is essential for employment, as well as other services on Grand Cayman. Improved access can be demonstrated by increased capacity and trip numbers when compared to the Future No-Build conditions. As of 2021, more than 7,000 people (more than 10% of the 2021 population of Grand Cayman) who work in George Town live in one of the three eastern districts (**Section 8.2.2.1: Employment Characteristics by District**).

Trip numbers were calculated from home base to work (east to west) during peak travel time in the morning and work to home base (west to east) during peak travel time in the evening. Trips between other destinations and districts of employment were also considered. As illustrated in **Table 8-17**, the Proposed Project is expected to provide a marked increase in the number of trips. A consideration for this component is that access to employment can be restricted for vulnerable groups based on lack of vehicle, lack of childcare, low income, disability, and others.

The Proposed Project is expected to offer 23% improvement in 2026 and 16% improvement in the 2074 "core" scenario by providing increased number of trips. In both future years, the Proposed Project receives a "Large Beneficial" significance on WebTAG's accessibility analysis scale.

Table 8-17: North Side/East End AM and PM Trip Numbers and % Improvement, 2026 and 2074

	Future No-Build	Proposed Project
2026 - Eastern Districts / Western Districts Work Trips		
North Side / George Town	327	413
North Side / West Bay	37	46
East End / George Town	123	141
East End / West Bay	3	5
Total AM and PM Car Trips	490	605
% Improvement from Future No-Build	**-**	**+23%**
2074 - Eastern Districts / Western Districts Work Trips		
North Side / George Town	800	961
North Side / West Bay	55	66
East End / George Town	757	841
East End / West Bay	31	34
Total AM and PM Car Trips	1,643	1,902
% Improvement from Future No-Build	**-**	**+16%**

Source: GCM

Employment Access

Accessibility can also be examined based on potential increases or decreases in job opportunities that could occur as a result of the Proposed Project. To assess a change in access to job opportunities, representative points in North Side and East End were selected based on the presence of existing residential neighbourhoods, and the number of jobs available within a morning commute of a certain duration (15, 30, 45, and 60 minutes) was calculated for the Future No-Build conditions and the Proposed Project for future years 2026 and 2074 (**Figure 8-4** and **Table 8-18**). Percent change in number of jobs available was then calculated.

The Proposed Project is expected to offer 13% improvement in 2026 and 55% improvement in the 2074 "core" scenario by providing better access to job opportunities. For 2026, the Proposed Project receives a "Moderate Beneficial" significance and for 2074, the Proposed Project receives a "Large Beneficial" significance on WebTAG's accessibility analysis scale.

Figure 8-4: Representative Locations for Employment Access Evaluation

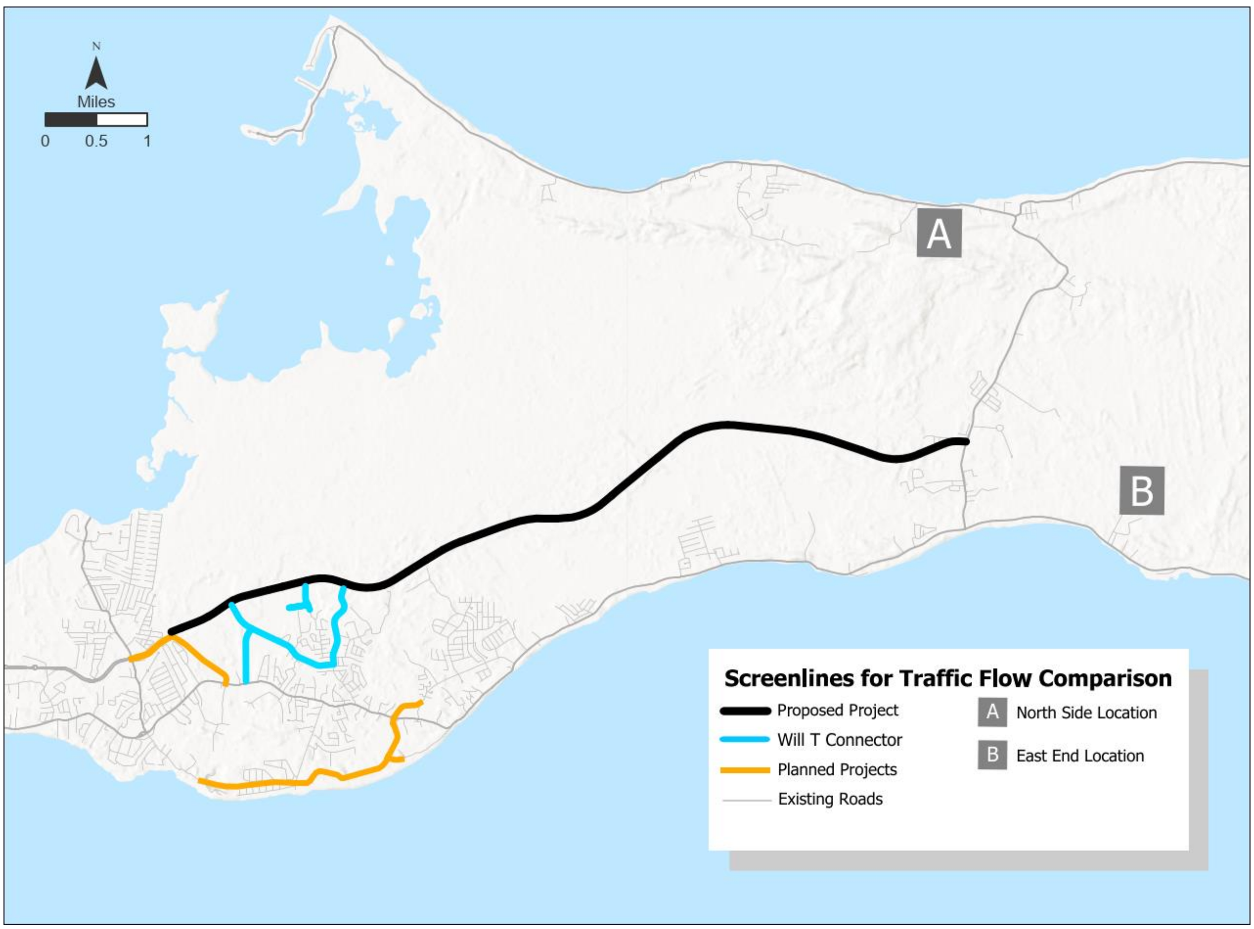


Table 8-18: Employment Access from North Side and East End

	Future No-Build	Proposed Project
2026		
Employment Access from North Side (no. of jobs)		
15 Minutes	1,187	1,536
30 Minutes	3,124	3,759
45 Minutes	4,833	6,407
60 Minutes	32,418	39,928
Employment Access from East End (no. of jobs)		
15 Minutes	1,437	1,707
30 minutes	3,581	3,759
45 Minutes	5,954	6,514
60 Minutes	38,983	39,964
Average Number of Jobs	**11,440**	**12,947**
% Improvement from Future No-Build	**-**	**+13%**
2074		
Employment Access from North Side (no. of jobs)		
15 Minutes	2,734	9,083
30 Minutes	9,119	13,100
45 Minutes	9,799	19,344
60 Minutes	13,102	28,108
Employment Access from East End (no. of jobs)		
15 Minutes	8,447	8,802
30 Minutes	9,715	13,038
45 Minutes	13,102	19,336
60 Minutes	19,404	21,863
Average Number of Jobs	**10,678**	**16,584**
% Improvement from Future No-Build	**-**	**+55%**

Source: GCM

Emergency Access

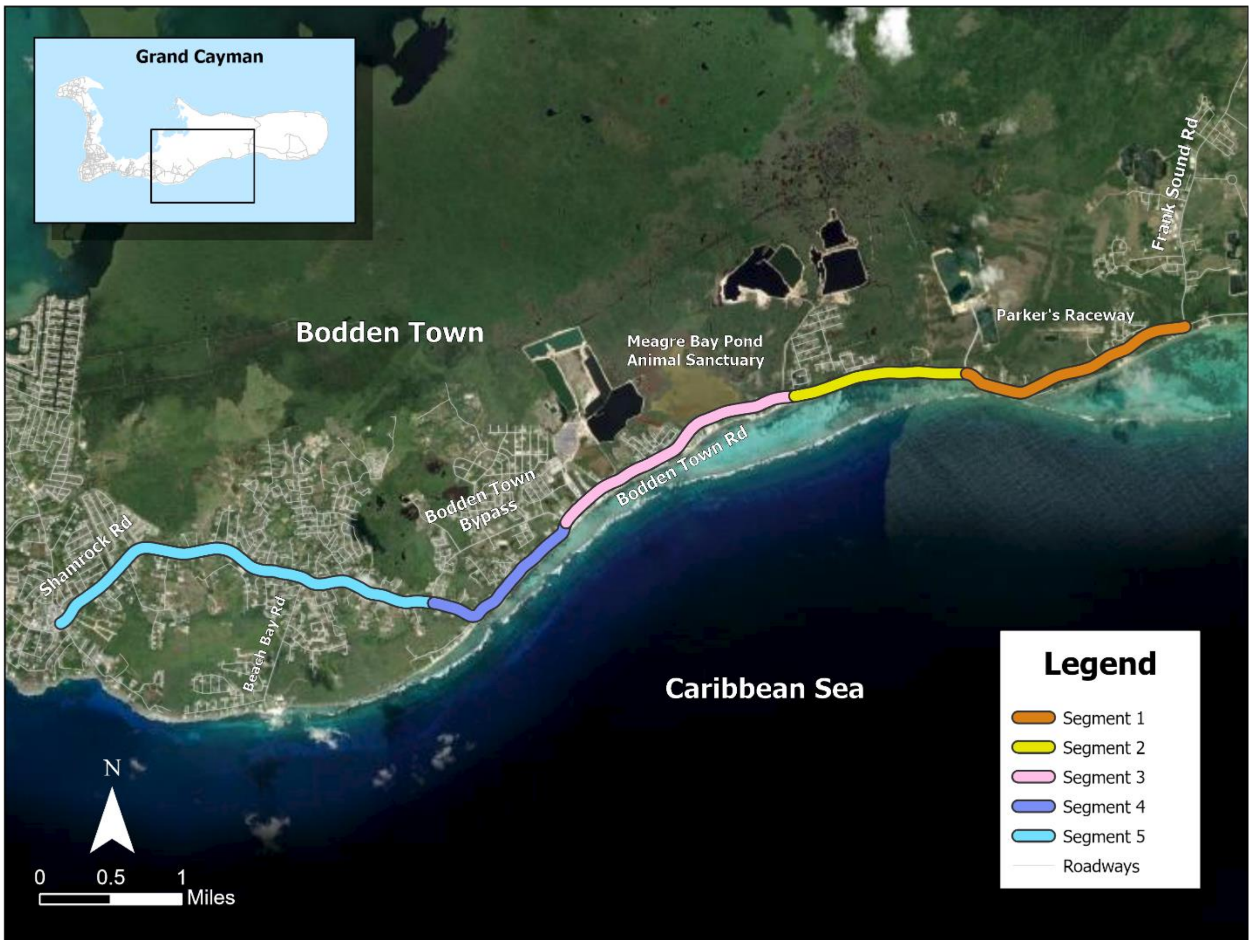
Access between eastern and western districts is also directly affected by events that could cause road closures along Bodden Town Road. Given that this is the only road that currently connects the western and eastern districts, events such as storms, crashes, and other disasters can cut off any movement (vehicular or other modes) between these districts. Although some services are offered in each district, such as the Health City Cayman Islands Hospital (also known as Shetty Hospital) in East End and government district health clinics, many important goods and services are located on the western side of the island, including the HSA Hospital and Doctor’s Hospital, the airport, the cargo port, the majority of jobs, and the majority of schools. A lack of accessibility due to a road closure can have severe effects on socio-economic quality of life, including the ability to reach emergency services, work, or school.

To assess this aspect of accessibility, the impacts of a road closure under the Future No-Build conditions were assessed for five segments along the coastal Bodden Town Road:

- Segment 1: Frank Sound Road to Betty Bay Pond Driveway
- Segment 2: Betty Bay Pond Driveway to Long Fellow Road
- Segment 3: Long Fellow Road to Bodden Town Bypass
- Segment 4: Bodden Town Bypass to Condor Road
- Segment 5: Condor Road to Hirst Road

Figure 8-5 visualizes the segments.

Figure 8-5: Road Closure Segments



The eastern population affected by an unavailable segment was calculated per segment (**Table 8-19**). If any of the segments depicted in **Figure 8-5** were impassable, the second east-west route that would be provided by the Proposed Project would prevent the eastern population from losing access to the west.

Table 8-19: Population Losing Access in the Event of Road Closure

	Future No-Build	Proposed Project
Road Closure – Population with Lost Access in 2026		
Segment 1	3,082	0
Segment 2	4,056	0
Segment 3	4,431	0
Segment 4	7,882	0
Segment 5	8,820	0
Road Closure – Population with Lost Access in 2074		
Segment 1	10,893	0
Segment 2	14,515	0
Segment 3	15,356	0
Segment 4	19,729	0
Segment 5	14,772	0

Source: GCM

To determine the percent change from the Future No-Build conditions, the population with lost access was subtracted from the total Grand Cayman population per year and per segment. This resulted in a population with maintained access between the west and the east should the road be closed due to an emergency. The population with maintained access per year for the Proposed Project was calculated and averaged, and the percent change from the Future No-Build was calculated (**Table 8-20**).

The Proposed Project percent improvement is expected to be 8% in 2026 and 13% in the 2074 "core" scenario. In both future years, the Proposed Project receives a "Moderate Beneficial" significance on WebTAG's accessibility analysis scale.

Table 8-20: Population with Maintained Access in a Road Closure and % Improvement from Future No-Build

	Future No-Build	Proposed Project
Road Closure - Population with Maintained Access in 2026		
Segment 1	73,291	76,373
Segment 2	72,317	76,373
Segment 3	71,942	76,373
Segment 4	68,491	76,373
Segment 5	67,553	76,373
Average	70,719	76,373
% Improvement from Future No-Build	**-**	**+8%**
Road Closure - Population with Maintained Access in 2074		
Segment 1	124,107	135,000
Segment 2	120,485	135,000
Segment 3	119,644	135,000
Segment 4	115,271	135,000
Segment 5	120,228	135,000
Average	119,947	135,000
% Improvement from Future No-Build	**-**	**+13%**

Source: GCM

8.3.1.2 Severance

Some transportation projects result in an increase in severance (an adverse consequence) while other projects result in no change (a neutral consequence) or a decrease in severance (a beneficial consequence). The analysis of severance focuses on pedestrians and their ability to reach parts of communities. In the case of this Proposed Project, because specific design features are included to benefit both pedestrians and other non-vehicular travel, allowing them to be considered separately, biking and other micromobility movements were considered as additional sub-factors alongside pedestrian movement.

To assess severance, vulnerable populations (households with children, households with no vehicle) were identified where data was available at the EA level. Population distribution in EAs intersected by the Proposed Project was assessed based on aerial imagery and known building locations. Based on the proposed new roadway alignment for the Proposed Project, a determination was made if the Proposed Project would travel through communities in the EAs it would intersect. Where community intersection would occur, the typical section was examined to determine the impact on community severance. Additions like multimodal paths that would facilitate walking, biking, and other modes of transport could reduce severance (i.e. improve access and mobility for micromobility users), whereas additions like concrete barriers along median strips or additional lanes could increase severance.

A summary of the number of households and the population that could potentially be affected by the Proposed Project is described in **Table 8-21**. The population shown is based on the EAs intersected by the Proposed Project, as well as by which households have children, or which households have automobiles (the data that was available at the EA-level necessary to conduct a severance analysis). To determine whether an EA would likely be affected by the Proposed Project, geospatial buildings data was examined to determine whether the Proposed Project would pass through neighbourhoods or near to any buildings. The Future No-Build was the baseline for assessment, against which increases or decreases in severance were evaluated.

Table 8-21: Summary of 2021 Vulnerable Populations Potentially Impacted by Severance

Scenario	Households	Households with Children	Households Without Automobile
Future No-Build	--	--	--
Proposed Project	1,069	373	142

The proposed improvement options for the Proposed Project would likely reduce severance, offering a beneficial impact for nearby communities. As described in **Section 8.1.6: Social Impact Appraisal**, severance becomes an issue if vehicle flows, or infrastructure create a barrier to pedestrian movement. In the case of the Proposed Project, facilities accommodating pedestrians, cyclists, and other modes of travel provide the opportunity to enhance community connectivity and access. Because data on specific pedestrian and other non-vehicular movement was not available for this study, two access points on the eastern side were chosen to represent community hubs that many people would need to access: Valu-Med Pharmacy in Bodden Town (Evron Plaza, 126 Anton Bodden Drive) and Clifton Hunter High School (**Figure 8-6**). Access to Valu-Med Pharmacy and to Clifton Hunter High School were both assessed by determining the 2074 population that could reach them with a 30-minute walk, bike, or micromobility commute (**Figures 8-7** and **8-8**).

Based on conditions such as traffic volumes, speed limits, shoulder widths, bike lane availability, and sidewalk availability, some roads are deemed suitable for biking and micromobility while being ill-suited for walking. For both the Future No-Build conditions and the Proposed Project, people would have better access to the Valu-Med Pharmacy when traveling by bike or micromobility than by walking because biking modes provide higher travel speeds, allowing people to travel farther distances compared to walking.

Figure 8-6: Location of Non-Vehicular Access Points

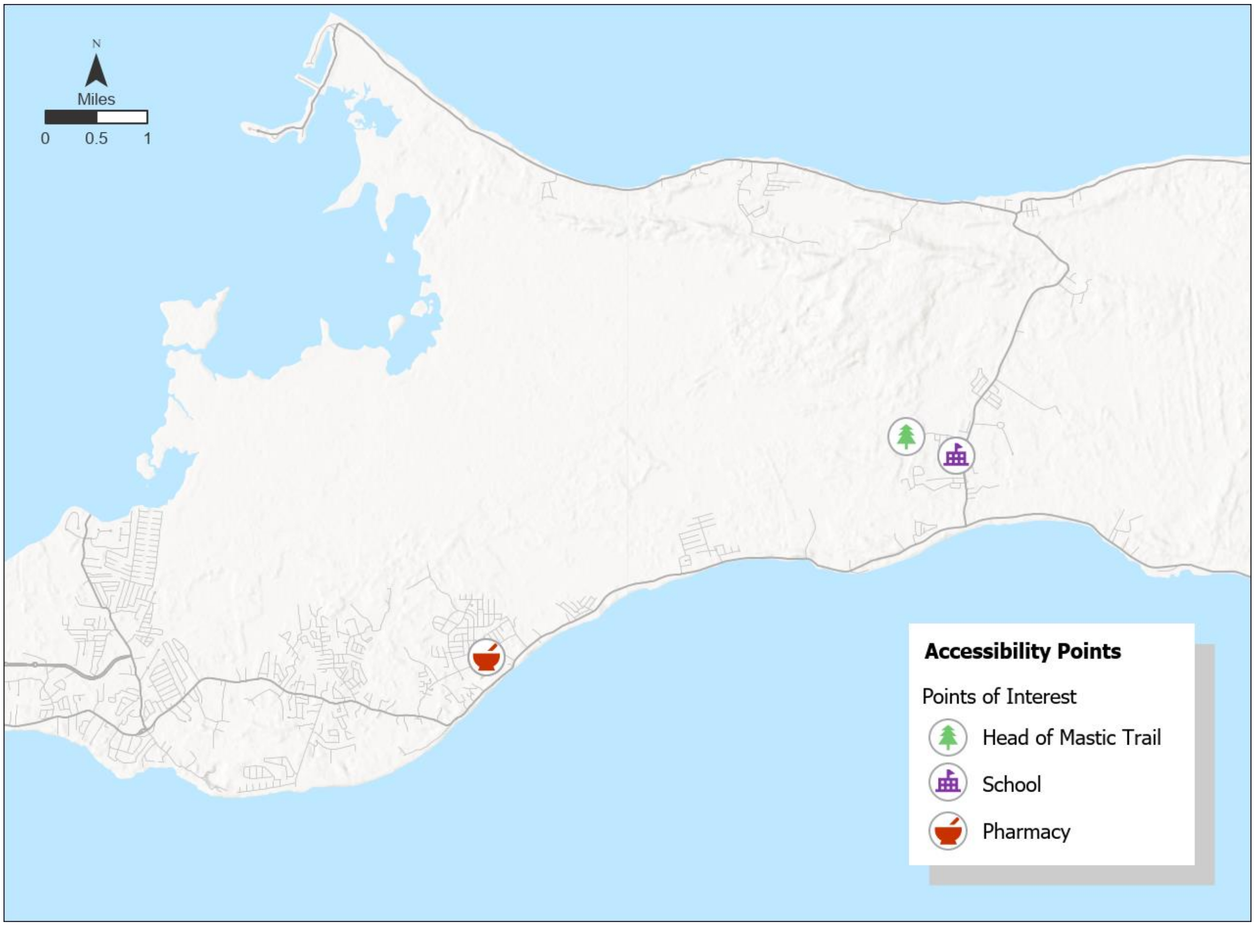


Figure 8-7: Access to Bodden Town Pharmacy within 30 Minutes by Mode of Travel

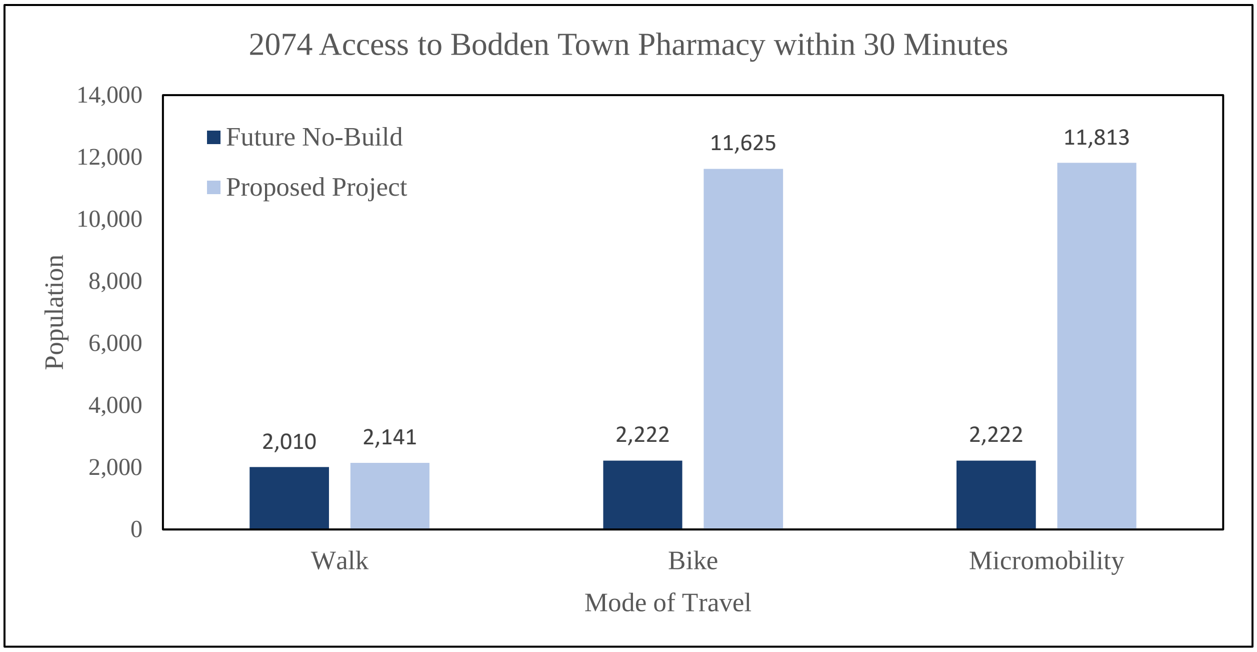
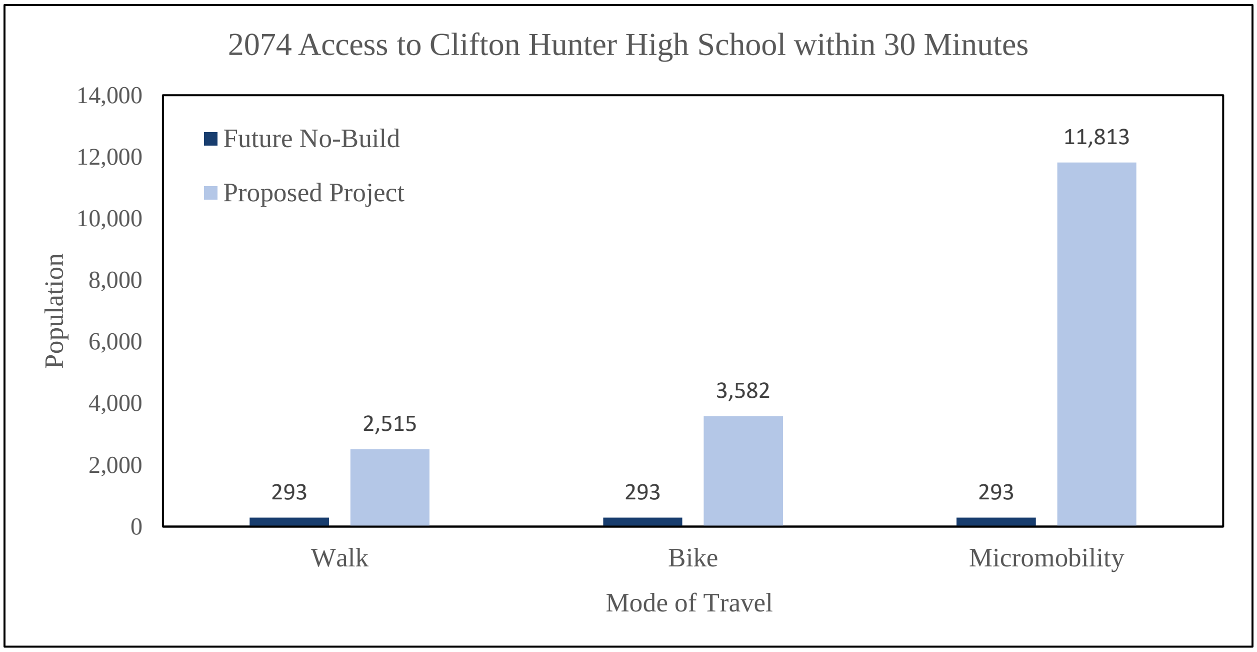
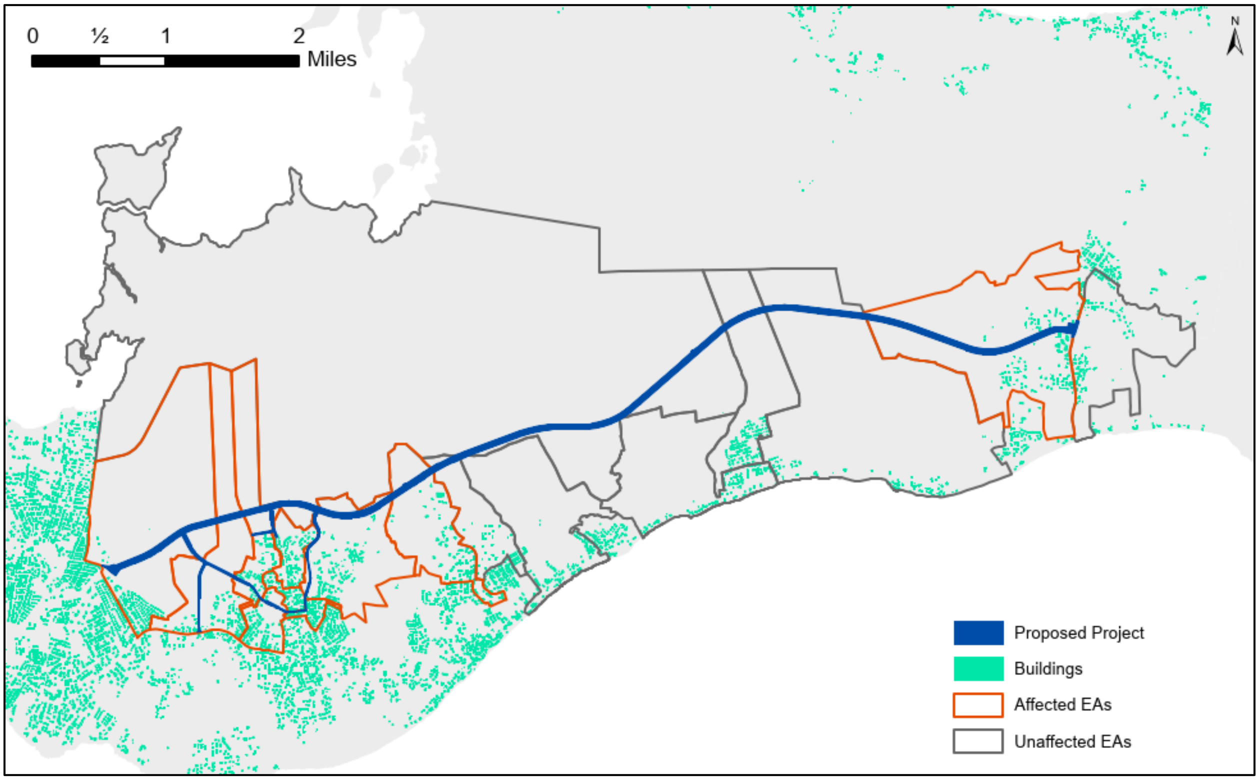


Figure 8-8: Access to Clifton Hunter High School within 30 Minutes by Mode of Travel



The Future No-Build would not alter the Baseline Conditions and therefore would maintain the existing amount of severance. The Proposed Project would intersect 18 EAs but would not directly impact the populations of all the EAs it intersects. Based on the evaluation of intersected EAs, the Proposed Project is expected to intersect the EAs outlined in orange (**Figure 8-9**), which includes 1,069 households: 373 households with children and 142 households without automobiles.

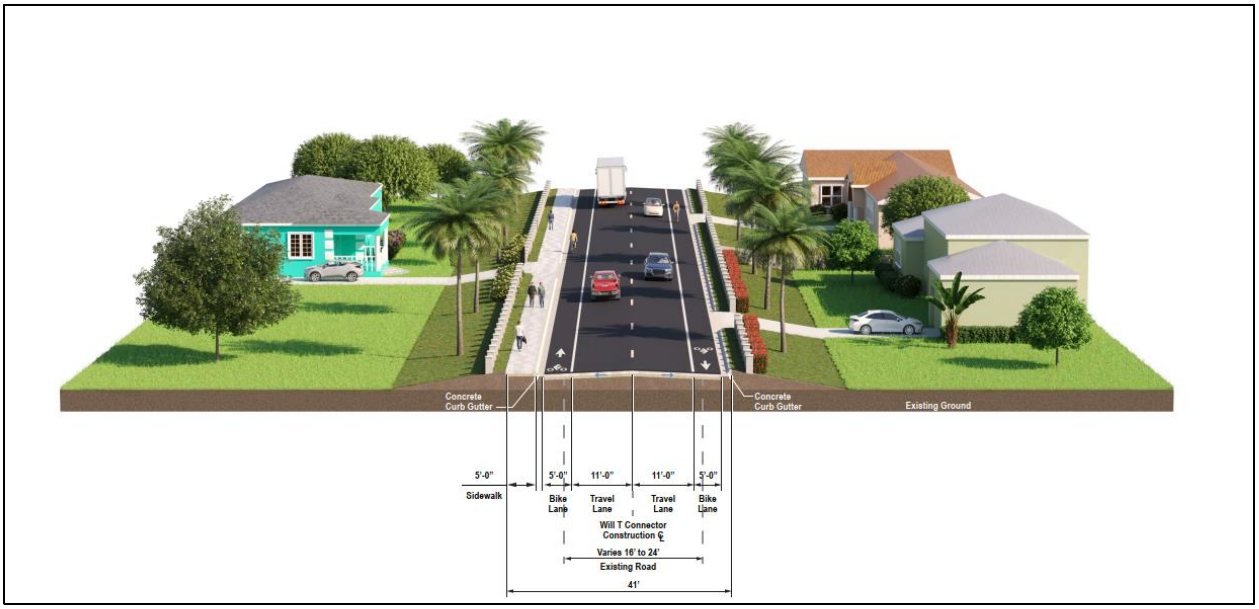
Figure 8-9: Proposed Project Potential Impact on Enumeration Areas



The Proposed Project includes the Will T Connector, which intersects neighbourhoods along existing roadway networks and comprises most of the affected households (809 out of 1,069). As shown in the anticipated typical section, **Figure 8-10**, the new facility would include a two-lane roadway with bicycle lanes located on both sides, as well as a sidewalk for pedestrian travel. While there is the potential for severance because of some increased traffic on these roadways, the provisions for bicycle and pedestrian travel, as well as the lack of a physical barrier, could reduce severance due to the increased mobility options for walking, biking, and other micromobility transportation modes. Two-way traffic volumes along the Will T Connector during peak hours in 2026 and the 2074 Core Scenario are not anticipated to be high. These volumes are anticipated to be approximately:

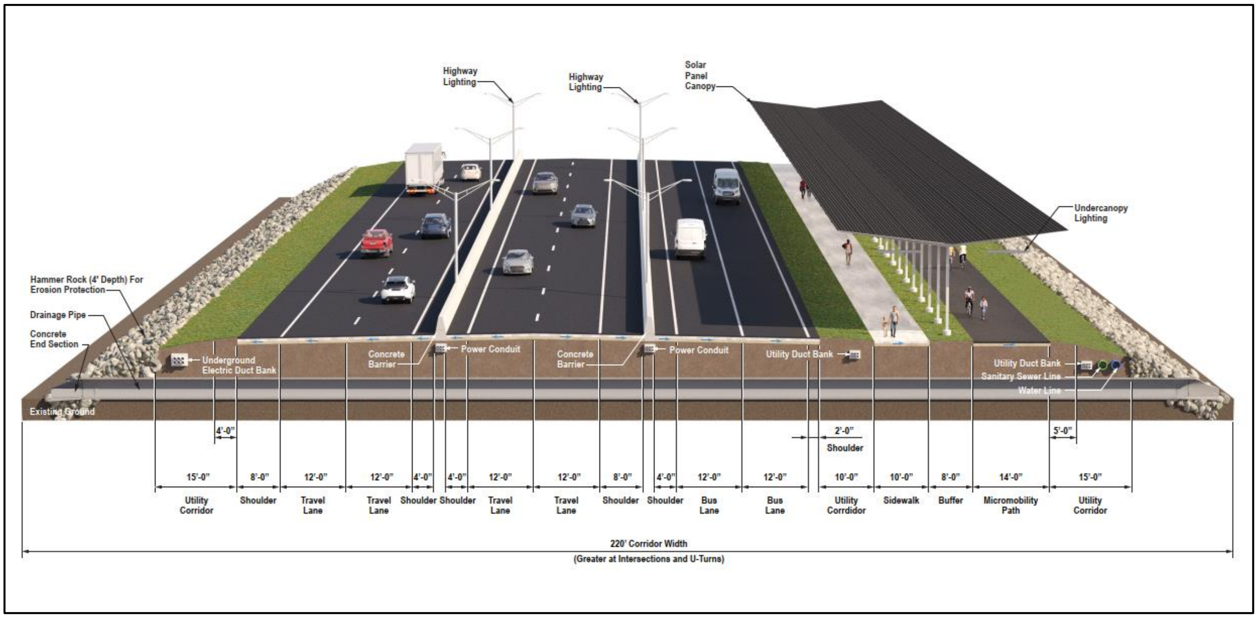
- 2026 AM: 333 vehicles
- 2026 PM: 126 vehicles
- 2074 Core AM: 461 vehicles
- 2074 Core PM: 172 vehicles

Figure 8-10: Will T Connector Typical Section



The remainder of affected households (260 out of 1,069) are located along the main east-west corridor for the Proposed Project. As shown in the anticipated 2074 cross-section, the new facility would include a physical (concrete) barrier, as well as a sidewalk for pedestrian travel and micromobility path for bicyclists on the southern side of the trail, offering the possibility of future connectivity with southern neighbourhoods **(Figure 8-11)**.

Figure 8-11: 2074 Section 2 and Section 3 Cross-Section



The total potentially affected population is greater than 1,000 persons, however there are limited amenities identified immediately north or south of the Proposed Project corridor. Due to the number of people affected but the limited number of destinations for non-vehicular populations to reach, the severance impact for the Proposed Project would be of "**Moderate Beneficial**" significance.

8.3.1.3 Journey Quality

Traveller Views

Travel is among the most common ways that people interact with external surroundings. Viewer response to aesthetics and visual resources can impact the overall character and quality of travel. WebTAG unit A4-1 describes impacts to traveller views relative to the surrounding landscape and the presence of impediments to views of the countryside or townscape. Scientific research indicates that humans prefer natural views (Beute & de Kort, 2019). For the purposes of this analysis, the presence of natural views versus views of man-modified and urban areas has been assessed in comparison with the Future No-Build conditions. Geospatial landcover and habitat data has been evaluated at the desktop level to determine the amount of natural space (not man-modified landcover classifications) the Proposed Project would pass through; for more information on landcover and habitat, see **Chapter 13: Terrestrial Ecology**.

The Proposed Project would provide 63% natural views along its length. Because the Proposed Project would provide natural views for over half the length of the journey, a three-fold increase over the Future No-Build conditions, the Proposed Project is assessed as a "**Moderate Beneficial**" impact.

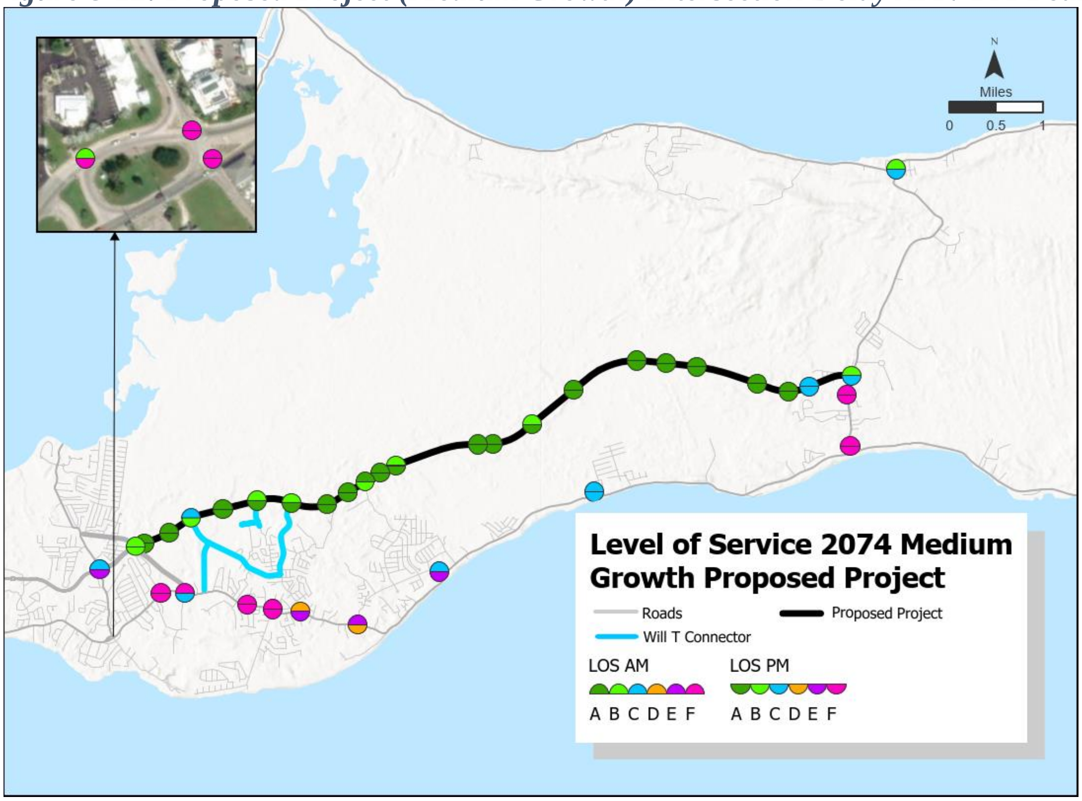
Traveller Stress

Traveller safety and perceptions of safety can influence the number of people utilising a transportation facility and impact the level of stress experienced as part of the overall journey. The Proposed Project is being designed to provide a safe transportation facility. This new facility would include specific design measures, such as adequate shoulder widths and turning radii, to maintain safety and minimise the possibility of traffic incidences. Traveller stress is assessed with the sub-factors of frustration, fear of potential accidents, and route uncertainty. This chapter assesses frustration and fear of potential accidents. The third category in WebTAG's Traveller Stress, route uncertainty, relates to unpredictable factors while travelling (e.g. travel times [assessed in **Section 8.3.1.1: Accessibility**], in-vehicle route signs, network maps, etc.) which are either assessed in other parts of the Social Impact Appraisal or require a more detailed level of design than is available at this stage, therefore route uncertainty is not considered here.

Frustration

One-way WebTAG defines the Traveller Stress sub-factor of frustration is the "ability to make good progress along a route." To assess this sub-factor, the ability to travel locally within Bodden Town was evaluated. As described in **Chapter 7: Transportation and Mobility**, a specific methodology was used to assess the amount of time a vehicle will be slowed when moving through an intersection, thereby calculating delay at each intersection. This delay per intersection is translated into a letter grade, known as LOS. LOS ranges from "A" (which indicates minimal delay) to "F" (which indicates failing characteristics such as high delay, systemic breakdowns, long queues, or slow travel). Letter grades A through D typically indicate "acceptable" operations whereas letter grades E and F indicate poor or "failing" operations. Existing and proposed intersections within the study area were assessed for LOS in 2026 and 2074 "core" scenario for the Future No-Build conditions and the Proposed Project. **Figure 8-12** demonstrates LOS for the Proposed Project in 2074. More information about LOS thresholds, including additional LOS maps for the Future No-Build and additional Proposed Project years, is available in **Chapter 7: Transportation and Mobility**.

Figure 8-12: Proposed Project (Medium Growth) Intersection Delay AM / PM Peak



To assess the ability to travel locally within Bodden Town and throughout the study area, LOS was examined during both AM and PM peak hours to determine the worst-case peak for each study area intersection; a percentage of intersections operating acceptably at LOS D or better was then calculated for both 2026 and 2074 (**Table 8-22**). This evaluation considered the conditions of these intersections under the Future No-Build conditions and the Proposed Project. For a complete list of intersections evaluated for the Future No-Build and Proposed Project in 2026 and 2074, see **Chapter 7: Transportation and Mobility**.

Table 8-22: Percentage of Intersections Operating at LOS D or Better (2026 and 2074)

% Operating at LOS D or Better	Future No-Build	Proposed Project
2026: Based on worst-case peak hour (AM or PM)	64%	100%
2074 "core" scenario: Based on worst-case peak hour (AM or PM)	14%	69%

Source: GCM & Associated Operational Model

The Proposed Project is anticipated to have 100% of intersections operating at LOS D or better in 2026, and 69% of intersections operating at LOS D or better in 2074. Therefore, the Proposed Project is assessed as a "**Large Beneficial**" impact.

Fear of potential accidents

To assess the potential impacts to journey quality and traveller safety, considering the possibility of crashes as a sub-factor, a qualitative evaluation has been performed by measuring the number of potential conflict points associated with the Proposed Project relative to the Future No-Build condition. Conflict points occur when two objects (e.g., vehicle/vehicle, pedestrian/pedestrian, vehicle/pedestrian, etc.) try to occupy the same space at the same time. More access points (e.g., cross-street intersections and driveways) along a roadway create more conflict points as vehicles enter and exit the roadway. People travelling along a corridor create opportunities for crashes at these conflict points, so roadways with higher traffic volumes result in more potential for conflicts. For this assessment, conflict points included both cross-street intersections and driveway access points. For this assessment it was assumed that all existing cross-streets and driveways access points would be maintained.

The Future No-Build was the baseline for the number of cross-street intersections and driveway access points along the existing east-west corridor made up of Shamrock Road and Bodden Town Road. By utilising the Proposed Project as the primary east-west corridor (instead of the existing coastal road) would reduce the number of cross-street intersections and driveway access points that motorists would have to pass by at least 75%. This is a result of bypassing the developed areas along Hirst Road, Shamrock Road, and Bodden Town Road and passing primarily through undeveloped areas. As a result, the Proposed Project is projected to have a "**Large Beneficial**" impact.

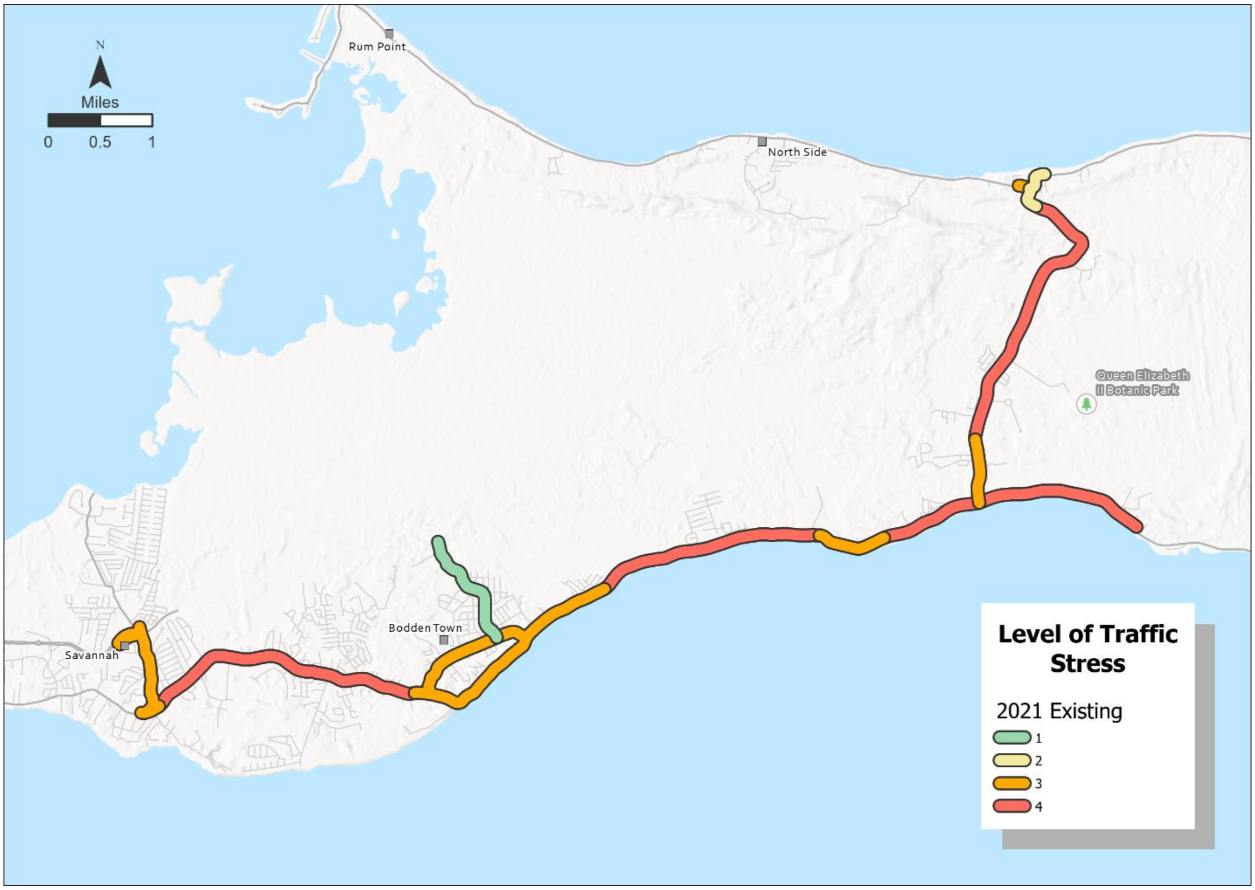
8.3.1.4 Option Values

The Proposed Project would not include implementation of new public transport services; however, the Proposed Project includes the preservation or anticipated provision for dedicated transit lanes, a sidewalk and micromobility path to accommodate future public transport and beneficial option values.

Under 2021 Baseline Conditions, Hirst Road, Shamrock Road, Bodden Town Road, and Frank Sound Road have LTS classifications of 3 or 4, resulting from lack of bicycle facilities, high vehicle speeds, and high vehicle volumes (**Figure 8-13**). As a result, vulnerable populations (see

Section 8.2.1.2) utilising these existing facilities, particularly those walking or biking, do not have the benefit of existing safe low LTS transportation options.

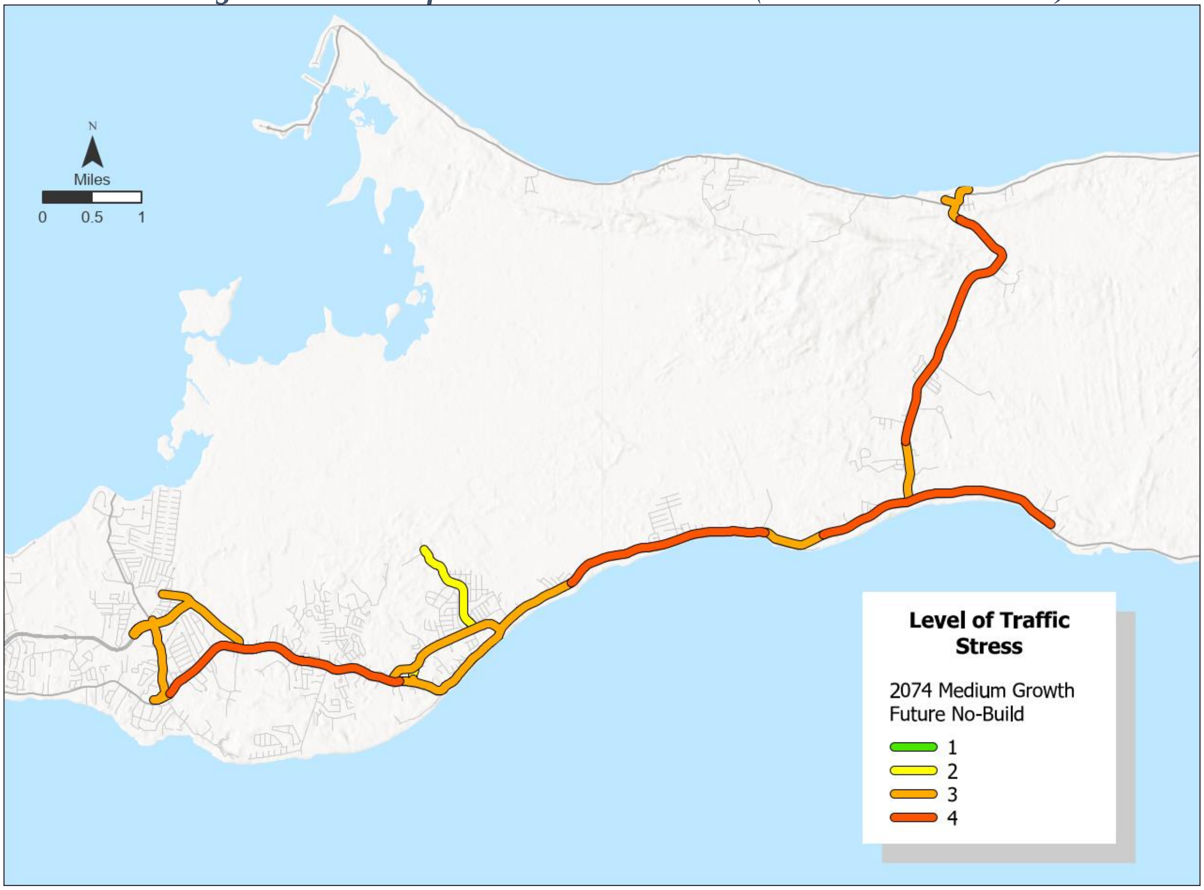
Figure 8-13: 2021 Baseline Conditions Bicycle LTS



Option and non-use value impacts were determined based on the assessed number of households in relevant districts (East End, North Side, and Bodden Town) for which the transportation intervention could potentially change the availability of transport services, including walking, biking, and other micromobility users.

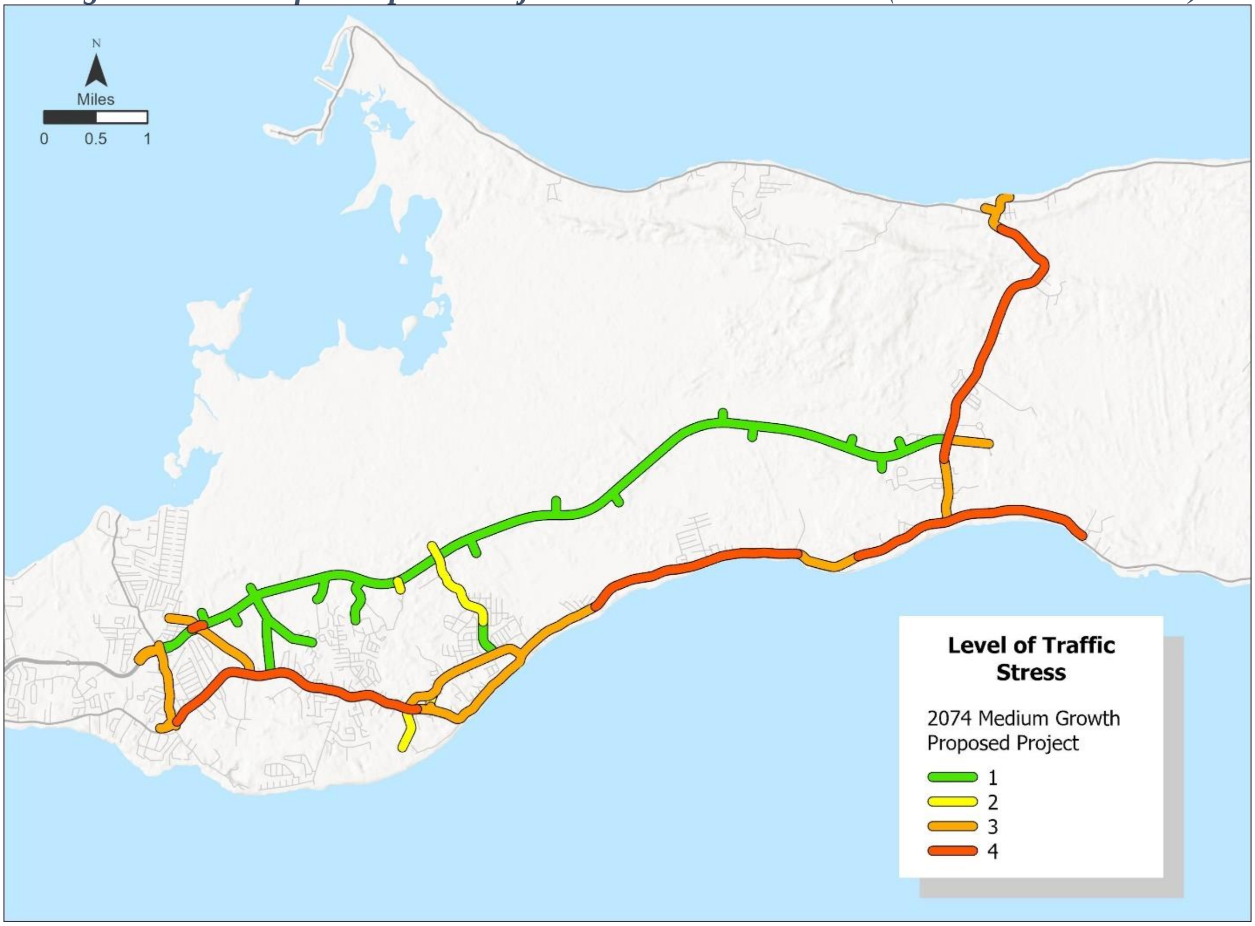
Future No-Build conditions would not result in the provision of new public transport services; bicyclists, pedestrians, and other micromobility users would continue to be subjected to poor LTS options (**Figure 8-14**).

Figure 8-14: LTS for the Future No-Build (2074 "Core" Scenario)



The Proposed Project could accommodate a 12 ft transit lane in both directions. The inclusion of this provision could potentially facilitate the provision of new transit services along the corridor, which could add new transit service directly to Bodden Town and North Side. The Proposed Project could also accommodate a separate sidewalk and a micromobility path, facilitating bicycle journeys and foot traffic, by 2074. The Proposed Project would have an LTS rating of 1 with the installation of a separated micromobility path, which is an improvement (**Figure 8-15**). Based on the current number of households in these districts, the Proposed Project is projected to have a "**Large Beneficial**" impact on the potential option value for future public transport provisions.

Figure 8-15: LTS for Proposed Project with Multi-Modal Path (2074 "Core" Scenario)



8.3.2 Construction Phase

Potential construction phase impacts were assessed, including the following:

- The removal/relocation of the Frank Sound Fire Station
- Noise and vibration impacts during construction (refer to **Chapter 9: Noise and Vibration** for more details);
- Potential for temporary roadway closures or diversions while connecting the Proposed Project to the existing roadway network and building of Will T Connector;
- Job creation;
- Effect of temporary workers (increase in housing demand/resources/road demand); and

Potential socio-economic impacts from the construction phase, detailed in **Table 8-23**, are associated with minor changes to the local economy through workforce implementation and aesthetics/quality of life due to temporary construction impacts.

Table 8-23: Construction Phase Impacts on Socio-Economic Receptors and Resources

Receptor / Resource / Impact Summary	Description / Potential Effect (*include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude	Sensitivity	Significance
Frank Sound Fire Station	The Proposed Project's eastern terminus ties into Frank Sound Road at the Frank Sound Fire Station. This would require removal of the fire station. Two fire stations are located on the western side of the island; the eastern side of the island would face longer emergency wait times due to this removal, if a new fire station was not built. This impact has a high likelihood/certainty of occurring.	Adverse Long-Term Regional	Intermediate Negative	Medium	Moderate Adverse
Resident Aesthetics "Quality of Life" / Noise impacts	Noise and vibration impacts during construction; refer to noise and vibration section. This impact has a medium likelihood/certainty of occurring.	See **Chapter 9: Noise and Vibration** for impacts.			
Resident Aesthetics "Quality of Life" / Viewshed impacts	Impacts to neighbourhood and natural views for certain residents due to construction equipment. This impact has a low likelihood/certainty of occurring.	See **Chapter 14: Cultural and Natural Heritage** for viewshed impacts			
Resident and Visitor Access and Mobility / Temporary Roadway Closures	Potential for temporary roadway closures or diversions while connecting the Proposed Project to the existing roadway network and building of Will T Connector. This impact has a high likelihood/certainty of occurring.	Adverse Short-Term Regional	Minor Negative	Low	Slight Adverse
Local Workforce / Income and Economics	Utilisation of primarily local workforce for final design and construction would result in a beneficial impact for local jobs and the regional economy. Utilisation of primarily foreign workforce for final design and construction would result in an adverse impact for local jobs and the regional economy. This impact has a high likelihood/certainty of occurring.	Beneficial / Adverse Short-Term Regional	Minor Beneficial	Low	Slight Beneficial
Temporary Workforce and Housing	Effect of temporary workers (increase in housing demand/resources/road demand). This impact has a medium likelihood/certainty of occurring.	Adverse Short-Term Regional	Minor Negative	Low	Slight Adverse

8.3.3 Operation Phase

Potential operation phase impacts were assessed, which includes the **Social Impact Appraisal** completed in **Section 8.3.1**.

Additional operation phase impacts assessed include:

- Contribution to regional economy via tourism access
- Noise impacts
- Viewshed impacts

Socio-economic impacts associated with the operation phase of the Proposed Project are detailed in **Table 8-24**. As described in **Section 8.1.5: Description and Assessment of Impacts**, the "magnitude" and "sensitivity" categories are considered within the evaluation of significance during the **Social Impacts Appraisal** stage of WebTAG. Therefore, the resources/receptors within the **Social Impacts Appraisal** have "Not Applicable" (N/A) in the "magnitude" and "sensitivity" categories in **Table 8-24.**

Table 8-24: Summary Table - Operation Phase Impacts on Socio-Economic Receptors and Resources

Receptor / Resource / Impact Summary	**Description / Potential Effect** *(include likelihood and certainty)*	**Type / Temporal / Geographic**	**Magnitude**	**Sensitivity**	**Significance**
Contribution to regional economy through increased tourism access	During operation, the Proposed Project may facilitate additional visits to East End and North Side tourist attractions, bringing additional spending to those facilities and to other local businesses. This impact has a medium likelihood/certainty of occurring.	Beneficial Long-Term Regional	Minor Beneficial	Low	Slight Beneficial
Noise impacts associated with the operation of the project	Noise and vibration impacts due to the operation of the Proposed Project. This impact has a high likelihood/certainty of occurring.	See **Chapter 9: Noise and Vibration**			
Changes to viewshed associated with operation of the Proposed Project	Viewshed impacts due to the operation of the Proposed Project. This impact has a low likelihood/certainty of occurring.	See **Chapter 13: Terrestrial Ecology**, and **Chapter 14: Cultural and Natural Heritage**			

Receptor / Resource / Impact Summary	Description / Potential Effect *(include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude	Sensitivity	Significance
Changes to development adjacent to the corridor	During operation, new development may occur adjacent to the roadway corridor.	See **Chapter 15: Summary of Direct, Indirect, Secondary/Induced, and Cumulative Impacts** for information about induced development.			
Social Impact Appraisal					
Residents of East End and North Side / Travel Time Benefits	The amount of time spent travelling from East District destinations to West District destinations – AM and PM. This can have impacts on employment access and access to education. This impact has a high likelihood/certainty of occurring. The % improvement would be 9% for 2026 and 17% for 2074 “core” Scenario.	Beneficial Long-Term Regional	N/A*	N/A**	Moderate /Large Beneficial
Tourists to/from Cruise Port / Travel Time Benefits	The amount of time spent travelling from the Cruise Port to tourism destinations in the Eastern Districts – AM and PM. This can have impacts on local businesses and the wider Caymanian economy. This impact has a medium likelihood/certainty of occurring. The % improvement would be 11% for 2026 and 19% for 2074 “core” Scenario.	Beneficial Long-Term Regional	N/A*	N/A**	Moderate /Large Beneficial

Receptor / Resource / Impact Summary	Description / Potential Effect *(include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude	Sensitivity	Significance
Residents of East End and North Side / Trip Numbers	Number of work trips to and from eastern and western districts (assuming people are travelling from east to west to access employment and from west to east to access home.) This impact has a high likelihood/certainty of occurring. The % improvement would be 23% for 2026 and 16% for 2074 "core" Scenario.	Beneficial Long-Term Regional	N/A*	N/A**	Large Beneficial
Residents of East End and North Side / Employment Access	Identifies the number of jobs available to residents in the North Side and East End within reasonable timeframes (15 and 30 minutes). This impact has a moderate likelihood/certainty of occurring. The % improvement would be 13% for 2026 and 55% for 2074 "core" Scenario.	Beneficial Long-Term Regional	N/A*	N/A**	Moderate/ Large Beneficial
Residents of East End and North Side / Emergency Access	Assesses the number of people able to access emergency services in western districts if Bodden Town Road is closed or obstructed. This impact has a high likelihood/certainty of occurring. The % improvement would be 8% for 2026 and 13% for 2074 "core" Scenario.	Beneficial Long-Term Regional	N/A*	N/A**	Moderate Beneficial

Receptor / Resource / Impact Summary	**Description / Potential Effect** *(include likelihood and certainty)*	**Type / Temporal / Geographic**	**Magnitude**	**Sensitivity**	**Significance**
Residents of the Will T Connector Area and along Bodden Town Road / Neighbourhood and community cohesion (Severance)	Neighbourhood and community cohesion has the potential to be disrupted by new roadway alignments (an adverse outcome), or to be enhanced by new micromobility or multimodal paths (a beneficial outcome). This impact has a moderate likelihood/certainty of occurring. The total potentially affected population is greater than 1,000 persons. While there is the potential for severance, the provisions for bicycle and pedestrian travel, could reduce severance due to the increased mobility options for walking, biking, and other micromobility transportation modes. Overall, the Proposed Project is anticipated to have a beneficial effect on severance.	Beneficial Long-Term Local	N/A*	N/A**	Moderate Beneficial
Residents and Visitors who use the EWA / Traveller Views	The aesthetic and visual resources that affect the overall character and quality of travel. These can be enhanced or adversely affected by the landscape a roadway passes through. This impact has a low likelihood/certainty of occurring. The Proposed Project would provide 63% natural views.	Beneficial Long-Term Local	N/A*	N/A**	Moderate Beneficial

Receptor / Resource / Impact Summary	Description / Potential Effect *(include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude	Sensitivity	Significance
Residents and Visitors who use the EWA / Traveller Stress - Frustration	Frustration is related to the "ability to make good progress along a route." This impact can be beneficial if frustration is likely to be improved and adverse if frustration is likely to be heightened. This impact has a low likelihood/certainty of occurring. The Proposed Project is anticipated to have 100% of intersections operating at LOS D or better in 2026, and 69% of intersections operating at LOS D or better in 2074. The Proposed Project is anticipated to increase the ability to travel locally within Bodden Town and the study area.	Beneficial Long-Term Local	N/A*	N/A**	Large Beneficial
Residents and Visitors who use the EWA / Traveller Stress – Fear of Potential Accidents	The possibility of crashes as an impact on the perception of the travellers using a roadway facility. This impact can be beneficial if the fear is likely to be improved and adverse if the fear is likely to be heightened. This impact has a low likelihood/certainty of occurring. Motorists using the Proposed Project instead of the coastal road to travel between eastern and western districts would reduce the number of cross-street intersections and driveway access points by at least 75%. This is a result of bypassing the developed areas along Hirst Road, Shamrock Road, and Bodden Town Road and passing primarily through undeveloped areas.	Beneficial Long-Term Local	N/A*	N/A**	Large Beneficial

Receptor / Resource / Impact Summary	Description / Potential Effect *(include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude	Sensitivity	Significance
Residents and Visitors / Non-vehicular modes of travel (Option Values)	The availability of public transport facilities or services to users and non-users (the value people perceive when having a transportation option available to them, not related to whether they intend to use it.) This can be assessed as beneficial or adverse, depending on if options are provided or removed. Assessed as a function of LTS - the safety and availability of non-vehicular modes of travel. This impact has a low likelihood/certainty of occurring. The Proposed Project could accommodate a 12 ft transit lane in both directions. The inclusion of this provision could potentially facilitate the provision of new transit services along the corridor, which would add new service directly to Bodden Town and North Side. The Proposed Project could also accommodate separate sidewalk and micromobility path, facilitating bicycle journeys and foot traffic, by 2074.	Beneficial Long-Term Regional	N/A*	N/A**	Large Beneficial

*magnitude is included within WebTAG's evaluation of significance (see **Section 8.1.5**)
sensitivity is included within WebTAG's evaluation of significance (see **Section 8.1.5).

8.4 Mitigation Measures

The following sections describe considerations for mitigating the adverse impacts described in **Section 8.3: Project Impacts**. Socio-economic mitigation considerations have the potential to minimise the potential impacts of the Proposed Project, including use of local employment, reviewing planning and zoning policies, and offering policy recommendations. **Table 8-25** details the characterisations used to evaluate the impacts after mitigation considerations have been applied.

Table 8-25: Impact Analysis Factors for Mitigation Considerations

Characterisation	Description	Quantitative Measure or Definition of Qualitative Categories
Magnitude	The size or degree of the effects compared against baseline conditions or reference levels, and other applicable measurement parameters (i.e., standards, guidelines, objectives)	**Negligible (N) |** Differing from the average baseline conditions to a very small degree, but within the range of the natural variation **Very Low (VL) |** Differing from the average baseline conditions to a small degree, but very minimally out of the range of the natural variation **Low (L) |** Differing from the average baseline and outside the range of natural variation but less than or equal to appropriate guideline or threshold value **Medium (M) |** Differing from the average baseline and outside the range of natural variation and marginally exceeding a guideline or threshold value **High (H) |** Differing from the average baseline and outside the range of natural variation and exceeding a guideline or threshold value
Geographic Extent	The geographic area over which the effects are likely to be measurable	**Limits of Disturbance (LOD) |** Occurs within the Proposed Project LOD **Outside Limits of Disturbance (OLOD) |** Occurs outside of the Proposed Project LOD, but within the identified Study Area
Timing	Considers when the environmental effect is expected to occur. Timing considerations are noted in the evaluation of the environmental effect, where applicable or relevant.	**Not Applicable (NA) |** Seasonal variations are not likely to change the effect **Applicable (A) |** Seasonal aspects may affect the outcome of the effect
Duration	The time period over which the effects are likely to last	**Short-Term (ST) |** The effect is reversible at the end of construction works **Medium-Term (MT) |** The effect is reversible within a defined length of time **Long-Term (LT) |** The effect is reversible over an extended length of time
Frequency	The rate of recurrence of the effects (or conditions causing the effect)	**Once (O) |** Effects occur once **Occasional (Oc) |** Effects that could occur randomly throughout the project lifetime **Regular (R) |** Effects can occur at regular intervals through construction and/or operation **Continuous (C) |** Effects are continuous throughout construction and operation
Reversibility	The degree to which the effects can or will be reversed (typically measured by the time it will take to restore the environmental attribute or feature)	**Reversible (R) |** The baseline conditions will recover to their standard after the construction works are completed **Partially Reversible (PR) |** Mitigation can return the baseline conditions **Not Reversible (NR) |** Mitigation cannot guarantee a return to baseline conditions

8.4.1 Construction Phase

During construction, mitigation considerations can be taken to prevent and/or reduce impacts to socio-economic receptors on- and off-site. This section, in tandem with **Table 8-26**, describes the potential mitigation considerations to address the impacts listed in **Section 8.3: Project Impacts**.

8.4.1.1 Frank Sound Fire Station

As a result of constructing the Proposed Project, the Frank Sound Fire Station would have to be demolished and relocated. The current fire station is located at the eastern tie-in to Frank Sound Road. Plans for its relocation and new construction are recommended during the procurement phase (prior to construction) to ensure the necessary emergency coverage remains. Coordination with the Ministry of Home Affairs and the Cayman Islands Fire Service is recommended to ensure service to the eastern districts are not disrupted during the relocation, and that the new location would be placed to continue to serve the same area population.

8.4.1.2 Noise and Natural Resource Disruptions

Construction noise and disruptions to natural landscapes can have an impact on the aesthetics of an area and the quality of life of residents or workers in that area. To preserve aesthetics and quality of life, mitigation considerations may include training of site personnel to raise awareness of noise and nearby noise sensitive receptors and the correct placement of construction staging sites to limit natural resource damage. The mitigation measure considerations for noise impacts and natural resource disruptions are described in **Chapter 9: Noise and Vibration** and **Chapter 13: Terrestrial Ecology**, respectively.

8.4.1.3 Traffic Disruptions

Construction of the Proposed Project could cause traffic disruptions at the eastern and western tie-in locations plus the areas along the Will T Connector. Recommendations include designing and implementing a traffic management plan before construction begins. Mitigation measures may include clear communication to the public before and during the disruption, signage, traffic diversions, rapid construction techniques, and time of day restrictions (e.g., avoiding work during peak traffic hours).

8.4.1.4 Workforce Demographics

Workforce needs for the construction of the Proposed Project have the potential to result in hiring foreign workers and non-Caymanian businesses, which diverts funds out of the Cayman Islands and may negatively impact the local workforce. Prioritisation of using a local workforce and local businesses would promote the local economy and provide work for Caymanians. Skilled foreign workers and businesses may be required for structures that require specialized staff (e.g. bridges). The NRA estimates that the workforce distribution would be 75% Caymanian and 25% foreign.

Table 8-26: Mitigation for Socio-Economics during the Construction Phase Summary

Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Frank Sound Fire Station	Loss of the Frank Sound Fire Station due to construction of the Proposed Project	A new fire station could be constructed in the same vicinity to replace the Frank Sound Fire Station. This station could include the same or better functionality and capacity to address emergencies and could serve the same population as the current station. Coordination with the Ministry of Home Affairs and the Cayman Islands Fire Service would need to occur to ensure the new location provides adequate emergency coverage to the Eastern districts.	N	OLOD	NA	ST	O	R	None	Not significant
			Assuming mitigation measures are applied, there would be negligible impacts to communities depending on access to this resource. The new fire station would be constructed in the vicinity of the old one, but Outside the LOD. Seasonal fluctuations do not apply. The duration of construction would be short-term, after which the new station would be operational. The frequency of construction would occur once. Mitigation efforts would reverse the effect of removing the current Frank Sound Fire Station by replacing it with a new one.							
Aesthetics "Quality of Life" – noise disruptions / natural resource disruptions	Disruptions to quality of life may include construction noise or disruptions to natural resources that add aesthetic quality to nearby landscapes.	See **Chapter 13: Terrestrial Ecology** and **Chapter 9: Noise and Vibration** for mitigation considerations.								

Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Access and Mobility – traffic disruptions due to construction and maintenance	Temporary road closures and traffic diversions at the Proposed Project's eastern and western tie-ins, as well as the Will T Connector, may lead to transportation delays and potential frustration for commuters. Future build years will necessitate phased traffic patterns, which could include lane shifts and periodic closures to accommodate construction activities.	Mitigation measures may include: • Communication, • Signage, • Traffic diversions, • Rapid construction techniques, • Time of day restrictions	VL	LOD	NA	ST	R	R	Minor to negligible	Not significant
			Assuming mitigation is applied, the magnitude of the effect is likely to be Very Low. The effects would occur within the LOD. Seasonal effects are not likely to change the outcome of the effect The duration of the effects would be reversible at the end of construction, therefore Short Term The effects would be Regular, meaning they could occur at regular intervals through construction and maintenance. The effects are reversible, meaning baseline conditions will recover after construction is complete							

<table>
<thead>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
</thead>
<tbody>
<tr><td rowspan="2">Income and Economics – workforce demographics</td><td rowspan="2">Utilisation of foreign workers or businesses may cause economic hardship to the Caymanian workforce and Caymanian businesses, including effects like occupying housing.</td><td rowspan="2">Promote the utilisation of local workforce and encourage local businesses to contribute as much as possible to the project. This can be done by requiring prioritization of a Caymanian workforce. The NRA estimates that the distribution of businesses, suppliers, and workers would be 75% Caymanian vs. 25% immigrants. Utilisation of outside sources is likely to be required for tasks that require specialized staff (e.g. bridge construction).</td><td>VL</td><td>OLOD</td><td>A</td><td>ST</td><td>C</td><td>R</td><td rowspan="2">Minor – small numbers of foreign workforce</td><td rowspan="2">Not significant – mitigation measures would limit hiring foreign workers instead of Caymanian</td></tr>
<tr><td colspan="6">Assuming mitigation is applied, the magnitude of the effect is likely to be Very Low, taking into account that hiring some foreign workforce is common for many Caymanian infrastructure projects.

The effects would occur Outside the LOD.

Seasonal variations may occur due to time-of-year construction restrictions or workforce availability.

The effect is Short-Term and would end when construction ended.

The effect would be Continuous throughout construction.

The conditions are Reversible, and the baseline economic condition would return once construction ended.</td></tr>
</tbody>
</table>

8.4.2 Operation Phase

Measures can be implemented to prevent and reduce impacts on and off-site during the roadway operation phase (post-construction). This section, in tandem with **Table 8-27,** describes potential mitigation measure considerations that could address the impacts described in **Section 8.3: Project Impacts**.

8.4.2.1 Future Planning, Zoning, and Development

Updated planning and zoning policies pertaining to the land around the Proposed Project could result in development occurring in areas that adversely impact existing communities and the natural environment. Adverse impacts may include displacing current communities to make way for new development, development in environmentally sensitive areas, and development that does not consider environmental conditions (e.g., flood-prone areas).

Mitigation considerations could include a review of planning and zoning policies and regulations to consider weaknesses that may allow for unsuitable development and offering recommendations for updates or revisions to those policies.

Recommendations may include provisions for defining the type of development that could occur (e.g., zoning, lot sizes, density); implementing anti-displacement policies to protect current residents (especially in low-income settings); setting aside areas for economic growth and environmental protection (e.g., re-zoning); and including construction requirements (e.g., elevated foundations/finished floor level and flood-resistant materials).

8.4.2.2 Severance (Will T Connector and Neighbourhoods)

The improvements to the Will T Connector suite of roadways and the new connection to the Proposed Project could facilitate additional roadway traffic through the Will T neighbourhood area, which in its baseline state receives little to no through-traffic. This traffic could make walking within this neighbourhood unappealing and less safe, increasing community severance.

To account for neighbourhood severance, clear pedestrian crossings could be located and marked. The current Will T neighbourhood roadways lack specific pedestrian facilities such as sidewalks. The improvements to the roadway network include provisions for pedestrian facilities (see **Section 8.3.1.2: Severance**). The recommendation is to include sidewalks and marked pedestrian crossings within the Will T neighbourhoods for pedestrian safety and ease of use. With these mitigation considerations implemented, community severance would either return to baseline conditions (e.g., the same number of people choose to walk) or would see an improvement (e.g., additional people choose to walk due to facility improvements).

Table 8-27: Mitigation for Socio-Economics during the Operation Phase Summary

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Aesthetics “Quality of Life” - Future planning</td><td rowspan="2">Updated planning/zoning policies may lead to development that adversely impacts existing communities and natural resources.</td><td rowspan="2">Reviewing existing planning and zoning policies and regulations to account for project components and providing recommendations for updates or revisions. Options include recommending specific economic growth/development areas and identifying potential environmental protection areas.</td><td>L</td><td>LOD/ OLOD</td><td>NA</td><td>LT</td><td>C</td><td>NR</td><td rowspan="2">Minor to moderate: with mitigation, some unsuitable development may occur, however it would be less frequent and less impactful than unmitigated development.</td><td rowspan="2">Somewhat significant – mitigation measures would limit planning that allowed for unsuitable or unchecked development, but would not completely eliminate it</td></tr>
<tr><td colspan="6">Assuming mitigation measures are applied, the magnitude of the impact would be Low.

The impact and mitigation would occur both within and outside the LOD.

Seasonal fluctuations are not likely to change the effect.

Development and planning updates would last for a Long-Term duration.

Development effects would be Continuous.

Development effects are intended to be permanent, and proper mitigation is intended to prevent them from occurring in unsuitable locations rather than returning to baseline conditions of no development, therefore this effect is Not Reversible.</td></tr>
</table>

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Aesthetics “Quality of Life” - Future zoning and development</td><td rowspan="2">Changes to future zoning may lead to development that adversely impacts existing communities and natural resources, or that places new development in areas unsuited for development (e.g. prone to flooding, too close to roadway facility).</td><td rowspan="2">Recommending updates or new policies to encourage the location of new developments that would minimise impacts to existing communities and natural resources, while promoting resilient future communities. Options include:
• recommending lot-size limits;
• recommending localized anti-displacement policies;
• recommending re-zoning appropriate areas (e.g. man-modified without trees land use) for denser development
• recommending re-zoning dense mangrove areas as areas unsuitable or less suitable for development;
• recommending housing construction requirements such as foundation elevations and flood-resistant materials; and
• recommending setbacks between housing and roadway facilities to reduce or eliminate roadway noise disturbance.</td><td>L</td><td>LOD/ OLOD</td><td>NA</td><td>LT</td><td>C</td><td>NR</td><td rowspan="2">Minor to moderate with mitigation; some unsuitable development may occur; however, it would be less frequent and less impactful than unmitigated development.</td><td rowspan="2">Somewhat significant – mitigation measures would include policy that prevents displacing existing communities in favour of new development and promotes resilient development in suitable areas but may not be able to eliminate unsuitable development completely.</td></tr>
<tr><td colspan="6">Assuming mitigation measures are applied, the magnitude of the impact would be Low.

The impact and mitigation would occur both within and outside the LOD.

Seasonal fluctuations are not likely to change the effect.

Policy updates or creation would last for a Long-Term duration.

Policy effects would be Continuous.

Long-Term policy effects would be intended to guide future development in the manner most suitable to promoting socioeconomic needs of Caymanians and environmental protection, rather than returning to baseline conditions. Therefore, this effect is Not Reversible.</td></tr>
</table>

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Access and Mobility – Severance (Will T Connector neighbourhoods)</td><td rowspan="2">Pedestrians may experience community severance as more vehicles use the Will T Connector facility</td><td rowspan="2">Evaluation of potential pedestrian crossing locations to reduce severance along the corridor. Pedestrian crossings at key locations would maintain neighbourhood connectivity and offer safe pedestrian options for within-neighbourhood travel.</td><td>VL</td><td>LOD</td><td>NA</td><td>LT</td><td>C</td><td>PR</td><td rowspan="2">Negligible</td><td rowspan="2">Not significant</td></tr>
<tr><td colspan="6">Assuming mitigation measures are applied, the magnitude of the effect would be Very Low.

The effect would occur within the LOD.

Seasonal effects would not apply.

The mitigation of implementing pedestrian crossings would cause any severance effects to be Short-Term in duration and reversible at the end of construction.

Any residual severance effects would be Continuous.

Severance is partially reversible; mitigation would allow for neighbourhood connectivity to return to close to baseline conditions and may offer an improvement over baseline in pedestrian safety and travel.</td></tr>
</table>

8.4.3 Summary of Socio-economic Mitigation Measure Considerations

Most impacts to socio-economic resources and receptors from the Proposed Project would be **beneficial** and would not require mitigation considerations. Most adverse impacts, including the removal of the Frank Sound Fire Station, traffic disruptions during construction, workforce considerations, and severance, can be adequately mitigated for to reduce the impact to an insignificant level. The consideration of possible new development along the corridor and additional mitigation considerations are described in **Chapter 15: Summary of Direct, Indirect, Secondary/Induced and Cumulative Effects**.

Additional information regarding implementation, responsibilities for implementation, any monitoring and reporting, and actions for non-compliance will be included as part of the separate EMP. Due to the phased development of the project, a review of the mitigation measures and design solutions will be continually evaluated during the design, construction, and operation phases to allow for successful mitigation.

9 Noise and Vibration

As stated in the ToR, 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 features. These effects may be increased if the construction is carried out during evening hours, when people are generally more sensitive to noise.

This assessment of noise and vibration considered 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.

This Noise and Vibration chapter of the ES comprises the following:

- Describes the methodology for noise and vibration assessments.
- Establishes Baseline Conditions within the Study Area.
- Identifies the potential benefits and adverse impacts due to the Proposed Project, including construction and operation phases.
- Assesses the significance of these potential impacts.
- Offers avoidance, minimisation, and mitigation considerations for the Proposed Project's potential negative noise and vibration impacts.

This chapter assesses the effects of the Proposed Project described in **Chapter 6: Proposed Project – Engineering Features**. Baseline Conditions, which equate to Existing Conditions, are established to demonstrate the existing noise environment within the study area. The Future No-Build conditions are consistent with **Chapter 7: Transportation and Mobility** and are used as a basis of comparison with the Proposed Project to characterize the noise impacts.

9.1 Assessment Methodology

This section describes the methodology used to assess noise and vibration elements during the EIA process. This methodology is in compliance with the ToR and follows established Cayman Islands law and international standards and practices, which are described in the following subsections.

9.1.1 Applicable Standards and Guidelines

Since the CIG does not have published standards or guidance on noise and vibration, this assessment relied on the UK's Design Manual for Roads and Bridges (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 that were considered are as follows:

Operational Noise:
- The Noise Policy Statement for England, 2010;
- Guidelines for Environmental Noise Impact Assessment, IEMA, 2014;
- Cayman Islands Development and Planning Act, 2021 Revision; and,
- Cayman Islands Development and Planning Regulations, 2024 Revision.

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

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

9.1.2 Data Sources Evaluated

The data sources that were utilised included:

- Topographic data from LiDAR LAS geospatial data provided by the Cayman Islands Land and Survey Department (received January 2024)
- Planning zone data from the Cayman Islands Planning Department (received July 2023)
- Parcel data from the Cayman Islands Lands & Survey Department (received July 2023)
- Aerial Imagery from Google Earth: June 2023 and September 2023

The conceptual roadway design and traffic volume data for the Proposed Project that were incorporated within the noise and vibration evaluation are described in **Chapter 6: Proposed Project – Engineering Features** and **Chapter 7: Transportation and Mobility**, respectively, of this ES document.

9.1.3 Incorporated Traffic Data Methodology

The traffic data utilised within this noise and vibration assessment was developed as part of the traffic evaluation, that contributes to multiple components for the studies of the Proposed Project. For noise modelling purposes of the Proposed Project analysis, bi-directional traffic for the PM peak hour condition was utilised as the estimated worst-case condition (**Appendix H.1: Traffic Data for Noise Analysis)**. See **Chapter 7: Transportation and Mobility** for details regarding the traffic analysis.

9.1.4 Assessment of Operational Noise Impacts

The overall quantitative, qualitative, and monetary evaluation of operational noise impacts relied on the UK Department for Transport "Transport Analysis Guidance" (WebTAG), Unit A3. Note that while night-time evaluation of noise impacts is applicable for some projects, it was determined inapplicable for the Proposed Project as the day and night-time traffic flows differ significantly; and it is not needed to support robust decision making (WebTAG Unit 3, Section 2.2.2 and 2.2.3).

The significance of the effect of traffic noise is dependent on both the sensitivity of the receptor and the magnitude of the impact at the receptor. Noise receptors analysed included, residential houses, parks, schools, prisons, and trails. 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 and both the lowest observable adverse effect level (LOAEL) and the significant observable adverse effect level (SOAEL) for the noise sensitive receptors within the Proposed Project corridor during the time periods when they are typically in use (e.g., schools would only need daytime LOAELs and SOAELs). The DMRB criteria defines noise effects as follows:

- 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).

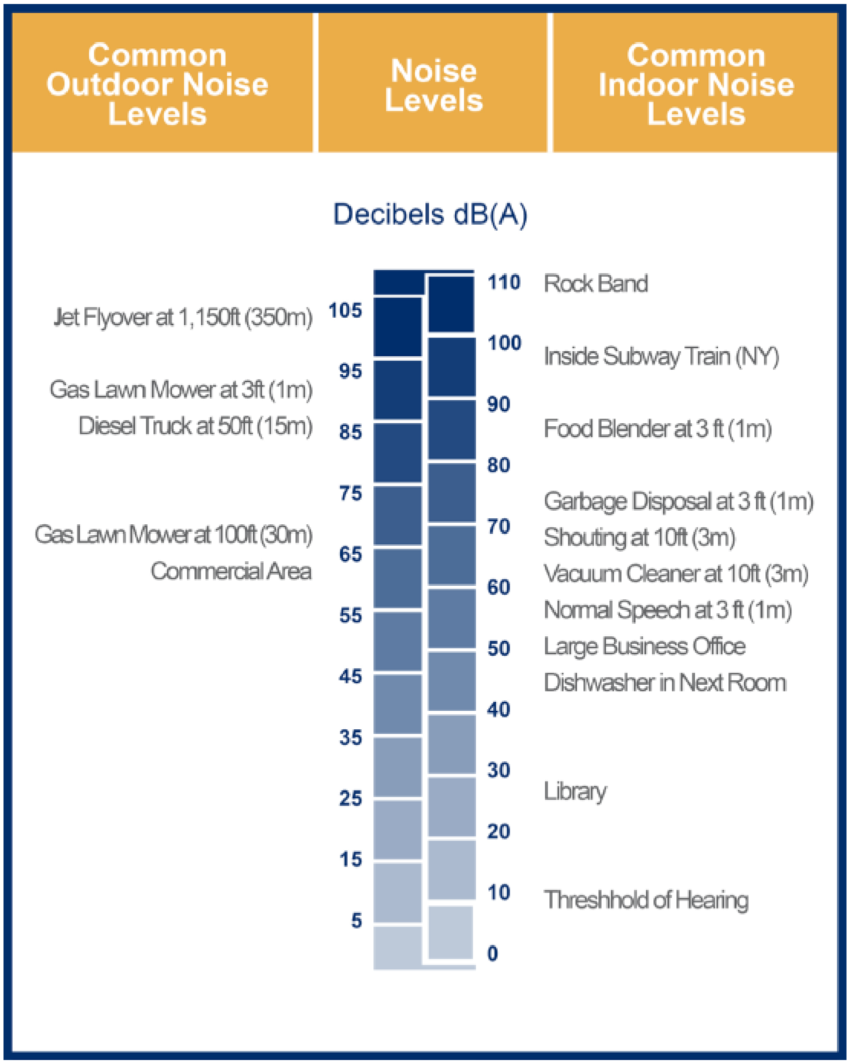
DMRB established LOAEL and SOAEL for daytime operational noise, as shown in **Table 9-1**. Comparison of noise levels with common indoor and outdoor noise sources are shown in **Figure 9-1** (LOAEL is most comparable to normal speech at 3 ft [1m] and SOAEL is most comparable to a gas lawn mower at 100 ft [30 m]).

Table 9-1: Operational Noise LOAELs and SOAELs

Time Period	LOAEL	SOAEL
Day (06:00 – 24:00)	55 dB $L_{A10,\ 18hr*}$	68 dB $L_{A10,\ 18hr*}$

** A-weighted, sound level in decibels (dBA) exceeded for 10% of each hour over the period 06:00 - 24:00 hours*

Figure 9-1: Noise Level Comparisons



Source: Indiana Department of Transportation, USA

The magnitude of impact for noise is based upon the predicted noise levels. According to the UK Green Book, which is the Central Government Guidance on Appraisal and Evaluation, "Costs and benefits should be calculated over the lifetime of an intervention. As a guideline, a time horizon of 10 years is a suitable working assumption for many interventions. In some cases, up to 60 years may be suitable, for example for buildings and infrastructure." After careful consideration of these parameters, the noise studies were completed using a 50-year time horizon, whereas year 2074 would represent the life-cycle year for construction and the common year used for the noise evaluations.

To evaluate noise impacts across the 50-year time horizon, 2026, 2036, 2046, and 2074 (Low, Medium / “core”, and High land use/population growth scenarios) were evaluated for both the Future No-Build and for the Proposed Project. The 2026 Future No-Build (opening year) was used as the baseline of comparison for all magnitudes of change. Note that while 2026, 2036, 2046, 2074-Low, 2074-Medium / “core”, and 2074-High scenarios are evaluated for noise and also included within the Cost Benefit Analysis. The noise impact levels from additional scenarios are included in **Appendix H.2: Predicted Noise Levels – Future No-Build** and **Appendix H.3: Predicted Noise Levels – Proposed Project**.

Table 9-2 displays the Magnitude of Change thresholds for the opening year (2026). **Table 9-3** displays the Magnitude of Change thresholds for the horizon year (2074). **Table 9-4** displays how humans perceive these changes in noise level.

Table 9-2: Magnitude of Change at Receptors Opening Year (2026)

Opening Year Magnitude	Opening Year Noise Change (dBA)
Major	≥ 5
Moderate	≥ 3 and < 5
Minor	≥ 1 and < 3
Negligible	< 1

* Source: DMRB – LA 111 Noise and Vibration

Table 9-3: Magnitude of Change at Receptors Horizon Year (2074)

Horizon Year Magnitude	Horizon Year Noise Change (dBA)
Major	≥ 10
Moderate	≥ 5 and < 10
Minor	≥ 3 and < 5
Negligible	< 3
Note: Difference in change of baseline noise level and operational noise level	

* Source: DMRB – LA 111 Noise and Vibration

Note: Difference in change of baseline noise level and operational noise level

Table 9-4: Human Perception of Noise Level Change

Change in Noise Level	Perception
+/- 3 dBA	Barely Perceptible
+/- 5 dBA	Clearly Perceptible
+/- 10 dBA	Twice/Half as Loud

* Source: FHWA Highway Traffic Noise Analysis and Abatement: Policy and Guidance

9.1.5 Assessment of Construction Noise and Vibration Impacts

The assessment of construction noise impacts relied on the DMRB Noise and Vibration Manual, reference document LA 111. Construction phases are estimated to occur in 2026, 2036, 2046, 2060, and 2074. Based on the DMRB, a study area of 984 ft (300 m) from the closest construction activity and 164 ft (50 m) from public roads, with the potential for an increase in noise level as a result of addition of construction traffic, is normally sufficient to encompass noise sensitive receptors. It is noted that construction noise levels shall be calculated at selected locations which are representative of all noise sensitive receptors in the study area (DMRB – LA111).

The magnitude of impact at noise sensitive receptors of construction traffic was determined in accordance with the DMRB – LA111 criteria shown in **Table 9-5**.

Table 9-5: Magnitude of Change During Construction

Magnitude of impact	Increase in base noise level 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

* Source: DMRB – LA 111 Noise and Vibration

Construction noise and construction traffic noise shall constitute a significant effect where it is determined that a major or moderate magnitude of impact will occur for a duration exceeding: 1) 10 or more days or nights in any 15 consecutive days or nights; 2) a total number of days exceeding 40 in any 6 consecutive months (DMRB - LA 111).

Based on the DMRB – LA111, a study area of 328 ft (100 m) from the closest construction activity is normally sufficient to encompass vibration sensitive receptors (DMRB – LA111). A qualitative assessment of vibration influences from the Proposed Project was undertaken to predict possible impacts to adjacent land uses. Assumptive adjustments to the source, along the path, and at the receivers were applied to identify the sensitivity and magnitude of the potential vibration effects.

9.1.6 Constraints and Limitations

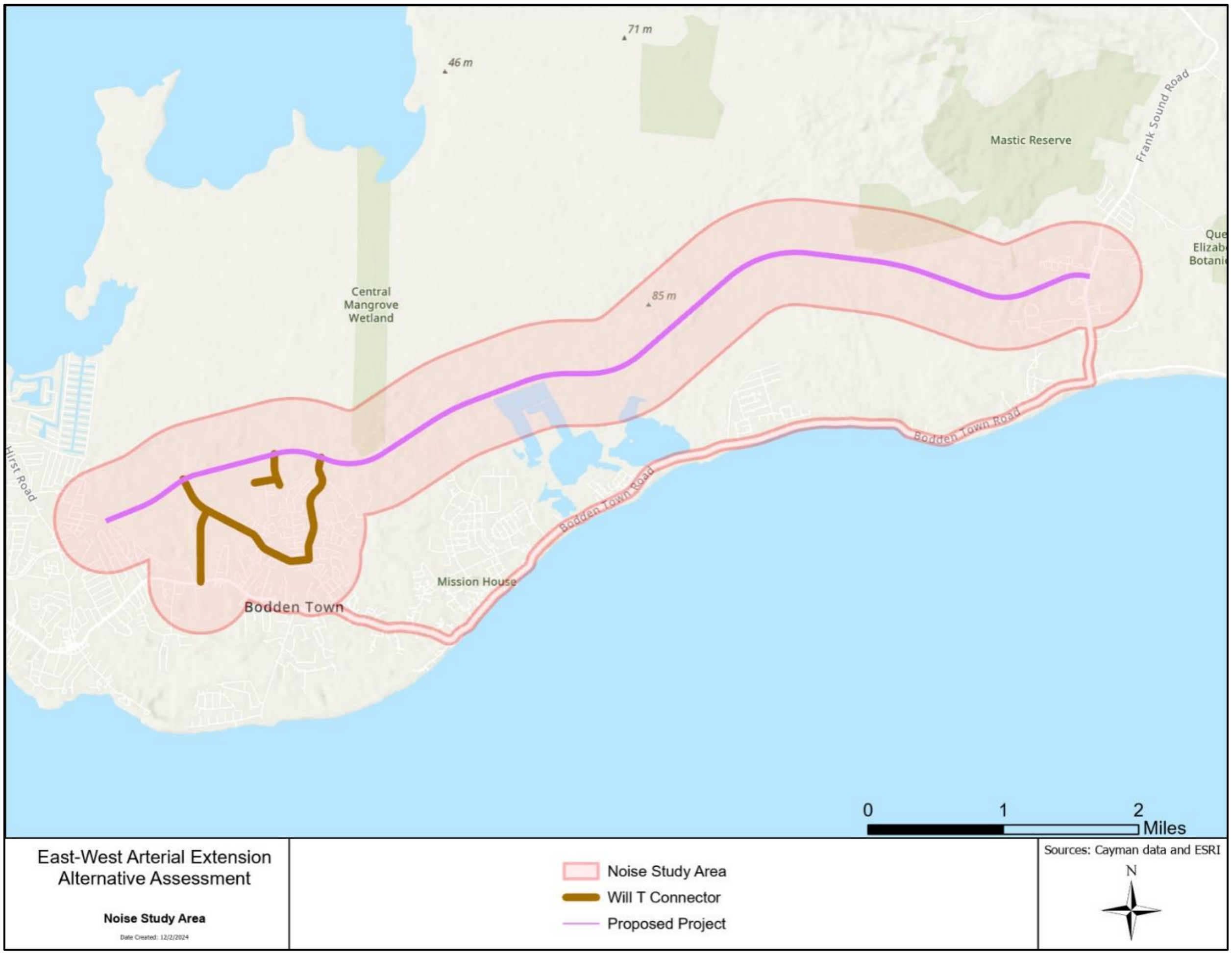
This assessment of noise and vibration has been completed at a conceptual level, based upon available data sources. Additional data sources are recommended to be collected during the detailed design phase in order to refine and confirm the results of this assessment including any new noise sensitive receptors, site specific topographic survey, any updated topographic data of the study area, and geo-technical survey.

9.2 Baseline Conditions

9.2.1 Noise Study Area

The study areas for operational noise impacts, construction noise impacts, and construction vibrational impacts were established individually based on conditions anticipated for each type of impact evaluated. The most conservative limits that were evaluated for the noise evaluation included 2,000 ft (600 m) from both sides of the centreline of the Proposed Project and 165 ft (50 m) from both sides of the centre line of the existing east-west roadway system (i.e. Shamrock Road and Bodden Town Road) as shown in **Figure 9-2**.

Figure 9-2: Noise Study Area



9.2.2 Identification of Receptors

After a comprehensive investigation and analysis of existing features and land uses, the sensitive noise receptors were identified within the noise study area. Noise receptors analysed included, residential houses, parks, schools, a prison, and a trail.

The following data sources were utilised to identify the noise receptors:

- Planning zone data from the Cayman Islands Planning Department (received July 2023)
- Parcel data from the Cayman Islands Lands & Survey Department (received July 2023)
- 2023 aerial imagery from Google Earth
- Field verification

Future planned and permitted developments were included where sufficient information was available (parcel boundaries, household locations). In addition to the identified noise receptors, noise contour lines were also established for the undeveloped and planned development areas.

The identified noise receptors that were analysed are shown in **Appendix H.4: Proposed Project 2074-Medium SOAEL Impact Mapping**.

9.2.3 Common Noise Environments (CNE)s

As previously described, the noise study area included 2,000 ft (600 m) along both sides of the Proposed Project and 165 ft (50 m) along both sides of the existing east-west coastal roadway system. After thoroughly reviewing the existing land use, the study area was divided into 11 CNEs (**Figure 9-3**). CNEs are a group of receptor sites that are exposed to similar locational ambient noise levels. The specific CNEs are identified by the first two digits of each receptor site. For example, site M01-01 is the number one site in CNE one, site M02-01 is the number one site in CNE two, and so forth. Each receptor site and its corresponding CNE are shown in **Appendix H.4: Proposed Project 2074-Medium SOAEL Impact Mapping**.

Table 9-6 describes the location, land use type and number of existing receptors within each CNE.

Table 9-6: Common Noise Environment Descriptions

CNE ID	Land Use Description	Land Uses Identified	Number of Receptors
01	This CNE is located east of Hirst Rd, primarily along Greenleaf Dr and Eldon St at the western project limits. The CNE is comprised entirely of residential land uses. The CNE's noise sensitive land uses include 77 receptors (M01-01-M01-77).	Residential	77
02	This CNE is located east of Hirst Rd along Jay Hubert Dr and Kimera Way, at the western project limits. The CNE is comprised primarily of residential land uses with one school. The CNE's noise sensitive land uses include 142 receptors (M02-01 to M02-142).	Residential and Educational	142
03	This CNE is located east of Hirst Rd and north of Shamrock Rd along Lancelot Dr, Watershed Cr, and Woodland Dr, at the western project limits. The CNE is comprised entirely of residential land uses. The CNE's noise sensitive land uses include 231 receptors (M03-01 to M03-231).	Residential	231
04	This CNE is in the western portion of the project area along Will T Dr and Minzett Dr. The CNE is comprised entirely of residential land uses. The CNE's noise sensitive land uses include 192 receptors (M04-01 to M04-192).	Residential	192

CNE ID	Land Use Description	Land Uses Identified	Number of Receptors
05	This CNE is in the western portion of the project area north of Shamrock Rd, along the Will T Extension. The CNE is comprised of residential land uses and a section of the Northward Prison. The CNE's noise sensitive land uses include 428 receptors (M05-01 to M05-428).	Residential and Institutional	428
06	This CNE is located south of Shamrock Rd in the middle portion of the project. The CNE is comprised entirely of residential land uses. The CNE's noise sensitive land uses include 61 receptors (M06-01 to M06-61).	Residential	61
07	This CNE is located between Beach Bay Rd and Frank Sound Rd, along Shamrock and Bodden Town Rd in the middle portion of the project. The CNE is comprised primarily of residential land uses, mixed with cultural (Mission House and Bodden Town Historic Pirate Cemetery), recreational (Harry McCoy Sr. Park), and commercial (hotels). The CNE's noise sensitive land uses include 200 receptors (M07-01 to M07-200).	Residential, Cultural, Recreational, and Commercial	200
08	This CNE is located north of Bodden Town Rd and west of Frank Sound Rd in the eastern portion of the project. The CNE is comprised primarily of residential land uses, mixed with cultural (cemeteries), and a civic centre containing recreational facilities (M08-01). The CNE's noise sensitive land uses include 40 receptors (M08-01 to M08-40).	Residential, Cultural, and Recreational	40
09	This CNE is located east of Frank Sound Rd and south of CNE 11 in the eastern portion of the project. The CNE is comprised entirely of residential land uses. The CNE's noise sensitive land uses include 11 receptors (M09-01 to M09-11).	Residential	11
10	This CNE is located west of Frank Sound Rd and south of the proposed EWA in the eastern portion of the project. The CNE is comprised primarily of residential land uses with commercial (hotels). The CNE's noise sensitive land uses include 33 receptors (M10-01 to M10-33).	Residential and Commercial	33
11	This CNE is located east of Frank Sound Rd and north of CNE 09 in the eastern portion of the project. The CNE is comprised entirely of residential land uses. The CNE's noise sensitive land uses include 18 receptors (M11-01 to M11-18).	Residential	18

9.2.4 Noise Modelling

Noise models were prepared for the Proposed Project, using the U.S. FHWA Traffic Noise Model (TNM) ® (TNM v2.5). TNM v2.5 is the current U.S. FHWA approved highway noise prediction model. Although TNM v3.1 was noted for possible use in the ToR, it is currently only used on projects at the discretion of the FHWA Division and State Department of Transportation. The implications of using TNM v3.0/3.1 include version inefficiency and instability, and potential noise level prediction underestimation. After careful consideration, the NRA, on January 3rd, 2024, approved the use of TNM v.2.5 for the noise evaluations being completed for this EWA EIA.

FHWA's TNM calculates sound levels similar to the UK's Calculation of Road Traffic Noise spreadsheet calculations; however, TNM is composed of numerous variables that allows for the calculation of multiple receptors at varying distances with variations accounting for vehicle type and speed, as well as topography and shielding in a more comprehensive way. This model creates a 3-dimensional view of the existing roadways, proposed roadways, noise-sensitive receptors, topography and uses traffic volumes, speeds and composition (i.e., cars, medium trucks, heavy trucks, busses, and motorcycles) to predict sound levels.

The data sources that were utilised for the TNM models include sources listed in **Section 9.1.2: Data Sources Evaluated**. The centreline of each lane of vehicular travel were included within the noise model. Traffic volumes, speeds, and compositions were applied based on the incorporated traffic data (**Section 9.1.3: Incorporated Traffic Data Methodology**) and **Appendix H.1: Traffic Data for Noise Analysis**.

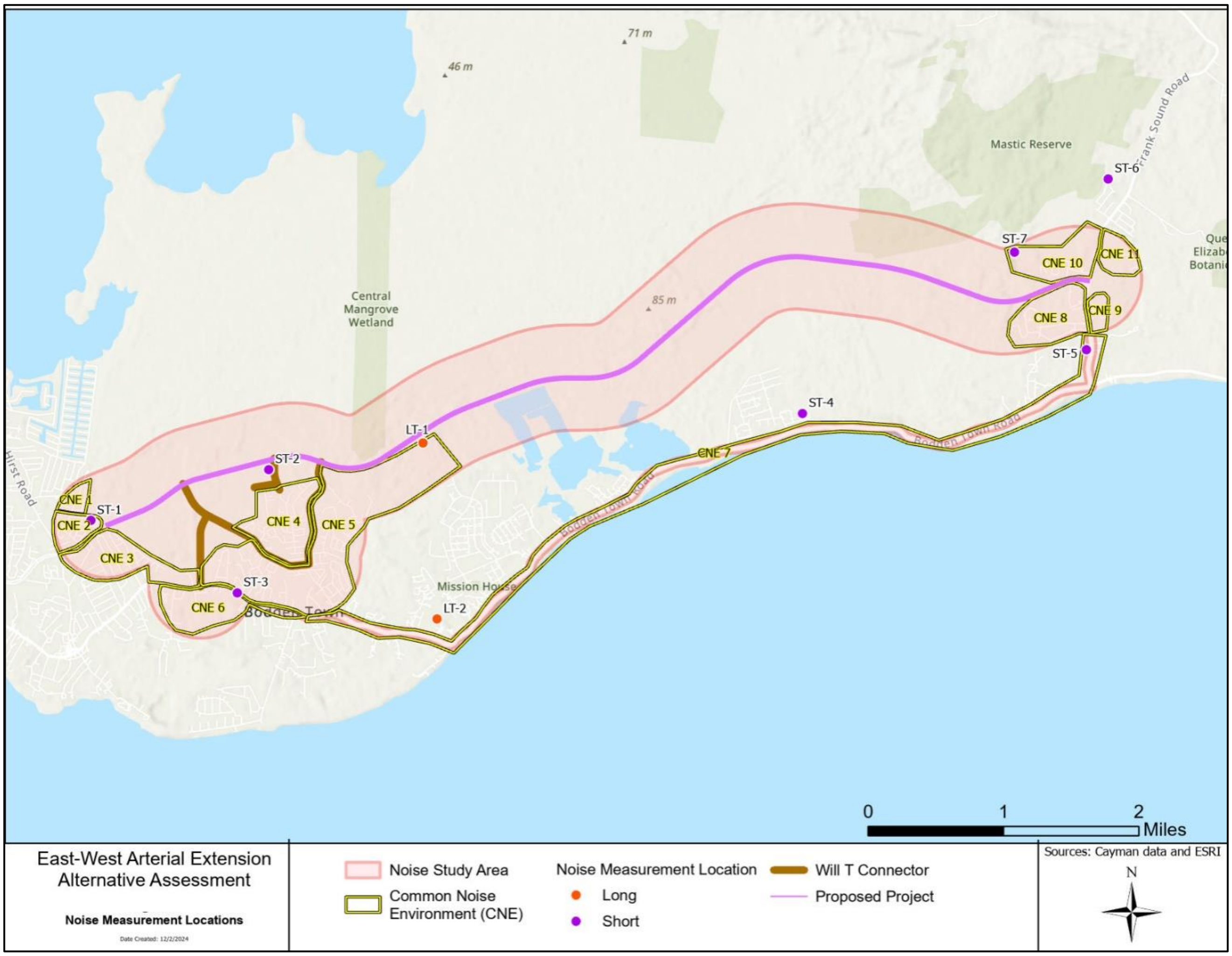
9.2.5 Noise Monitoring

To assess existing ambient noise conditions within the study area, both short-term and long-term noise monitoring was conducted utilising Rion NL42 Type 2 noise metres. The location of each short-term and long-term noise monitoring site in relation to the Proposed Project, is shown in **Figure 9-3**. Pictures of the noise monitoring sites are shown in **Figure 9-4**.

Short-term, 20-minute monitoring was conducted to evaluate the accuracy of the TNM model at three locations (ST-03, ST-04, and ST-05). Short-term monitoring was also conducted at four other locations (ST-01, ST-02, ST-06, and ST-07) to record existing ambient conditions in areas not currently affected by roadway noise.

Two long-term (LT-01 and LT-02), monitoring sessions were completed to obtain the overall existing ambient conditions for a longer period. The two long-term sites were measured for a 23-hour period. It was intended to measure at these locations for a total of 24 hours; however, weather conditions caused the measurements to end one hour early.

Figure 9-3: Noise Measurement Locations



A description of the noise monitoring duration and location for each site along with the existing monitored decibel readings are provided in **Table 9-7**.

Table 9-7: Noise Monitoring

Site	*Monitored Level dBA*	*Description*
ST-01	47.8	• Short term (20-minutes) existing ambient measurement • Located in a residential development along Woodland Drive
ST-02	46.0	• Short term (20-minutes) existing ambient measurement • Located adjacent to a residential area at the end of Will T Drive
ST-03	65.2	• Short term (20-minutes) measurement for TNM validation • Located in a residential area at the intersection of Shamrock Road and Midnight Road
ST-04	50.3	• Short term (20-minutes) measurement for TNM validation • Located in a residential area along Cherry Tree Drive
ST-05	60.4	• Short term (20-minutes) measurement for TNM validation • Located in and open area along Halley Street, adjacent to Frank Sound Road
ST-06	46.4	• Short term (20-minutes) existing ambient measurement • Located adjacent to the entrance to the Mastic Trail
ST-07	41.7	• Short term (20-minutes) existing ambient measurement • Located adjacent along Botanic Road, the entrance to Queen Elizabeth II Botanic Park
LT-01	49.0	• Long term (24-hour*) existing ambient measurement • Located along a residential driveway, adjacent to Lookout Road
LT-02	61.6	• Long term (24-hour*) existing ambient measurement • Located at the intersection of Spice Road and Shamrock Road

* *Weather conditions caused measurements to register for 23-hours rather than 24-hours*

Figure 9-4: Noise Monitoring; Short Term (left) and Long Term (right)

The monitored equivalent continuous sound level (L_{eq})in the noise study area ranged from 41.7 dBA to 65.2 dBA. Shamrock Road, Bodden Town Road, and Frank Sound Road are the dominant sources of traffic noise within the study area. The data sheets completed during the noise monitoring, which include additional details regarding the noise monitoring at each location, can be found in **Appendix E - Shortlist [Alternatives] Evaluation: Attachment D – Noise – Assessment of Alternatives**. See **Section 9.1.4** for noise level comparisons to common indoor and outdoor noise sources and significance thresholds.

9.2.6 Noise Model Validation

Computer modelling is the accepted technique for predicting noise levels associated with traffic-induced noise for both the Future No-Build and Proposed Project. The modelling simulations begin only after the completion of the model validation. The noise model validation process ensures that the TNM provides a reasonable approximation of reality and makes any adjustments to the model to bring it within a desired range. This was accomplished by comparing the monitored noise levels to the noise levels predicted by TNM, using traffic volumes and speeds that were observed during the monitoring process (i.e., 20-minute traffic data was converted to one-hour traffic data for validation of the model). This validation ensures that reported changes between the existing and future design year conditions are due to changes in traffic, and not discrepancies between monitoring and/or modelling techniques. A difference of plus or minus 3 dBA or less between the modelled and monitored levels is acceptable since this is the limit of change that is barely perceptible by a typical human ear. A summary of the model validation is provided in **Table 9-8**.

Table 9-8: Noise Model Validation

Site	Monitored Level dBA	Modelled Level dBA	Difference (Mon – Mod)
ST-01*	47.8	--	--
ST-02*	46.0	--	--
ST-03	65.2	65.0	0.2
ST-04	50.3	49.5	0.8
ST-05	60.4	59.9	0.5
ST-06*	46.4	--	--
ST-07*	41.7	--	--
LT-01*	49.0	--	--
LT-02*	61.6	--	--

* *Identifies existing ambient noise levels*

As shown for all three of the validation sites, the difference between the monitored and modelled noise levels ranges from 0.2 to 0.8 dBA. The predicted levels that were modelled in TNM can differ from the recorded levels due to several additional factors. Such factors include:

- atmospheric conditions
- existing shielding by structures that may be difficult to model
- pavement properties that differ from the average pavement required for use in TNM
- complex roadway, terrain, and/or receptor geometry
- the representativeness of louder vehicles which pass by the sound level metre during the measurement period

Other types of factors (i.e., non-traffic related noise) during the monitoring events also cannot be replicated in TNM. These non-traffic related noise effects can include the following:

- airplane overflights
- compression release engine brakes (commonly known as Jake or Jacobs Brakes)
- transit events
- emergency sirens
- heating and air conditioning systems
- lawnmowers (i.e., motorized lawn care activities)
- backup alarms

The noise from these external factors was removed from the noise monitoring data when it had a noticeable effect on the monitored noise levels. There are also factors in the noise model that may cause differences with the measured noise levels, including level of detail in terrain modelling and the degree of inclusion of smaller elements such as hard ground zones, tree zones and sparse rows of buildings.

Overall, the predicted noise level for all three validation monitoring sites was within 3 dBA of the monitored levels, and therefore, this meets the criteria for validation of the TNM models.

9.3 Project Impacts

This section describes the potential impacts to noise and vibration that are estimated to occur as a result of the Proposed Project. The Future No-Build condition is also included as a basis for comparison to demonstrate the impacts and benefits of the Proposed Project. The Proposed Project is described in **Chapter 6: Proposed Project - Engineering Features** and traffic evaluations in **Chapter 7: Transportation and Mobility**. **Chapter 15: Summary of Direct, Indirect, Secondary/Induced and Cumulative Effects** includes Secondary, Induced, and Cumulative impacts.

Due to the phasing of the construction timeline, the future years 2026, 2036, 2046 and three growth scenarios for 2074 (projected low, medium and high population/development growth) were analysed for this discipline where appropriate.

9.3.1 Construction Phase

The construction assumptions were estimated based on available conceptual design information prepared for the Proposed Project (see **Chapter 6: Proposed Project – Engineering Features** for conceptual design), coordination with the NRA on equipment availability, and subject to change in later detailed design phases. Conservative estimates were utilised where appropriate. A potential list of equipment to be used for road construction was developed as shown in **Table 9-9** and applied for this analysis.

Table 9-9: Potential Construction Equipment

Equipment Type
Pavers
Rollers
Excavators
Graders
Tractors/Loaders/Backhoes
Crawler Tractor/Dozers
Dumpers/Tenders
Cranes
Bore/Drill Rigs
Rough Terrain Forklifts
Surfacing Equipment

The estimated months of construction by phase, crew size, workdays, and truck trips per day were established through coordination with the EWA EIA engineering team (**Table 9-10**). It was also assumed that each worker would utilise one personal vehicle to travel to and from the work site. Material delivery operations were estimated to utilise a dedicated fleet of 10-20 delivery vehicles (trucks), with daily delivery (truck) trips ranging from approximately 46 to 333 depending on anticipated construction phase year at this conceptual design level; these assumptions are subject to change based on the detailed design phase outside of this EIA.

Table 9-10: Estimated Potential Commuting and Delivery Vehicles

Year	Estimated Months of Construction for Phase	Estimated Crew Size (Commuting Vehicles)	Estimated Workdays	Estimated Delivery Truck Trips per Day
2026	24	200	697	333
2036	24	200	697	218
2046	24	200	557	129
2060	24	200	557	124
2074	12	200	279	46

9.3.1.1 Construction Noise Impacts

Estimated construction related noise impacts were evaluated consistent with the methodology in **Section 9.1.5: Assessment of Construction Noise and Vibration Impacts** from the DMBR LA111. The Future No-Build was assumed to require no new construction, and therefore, it was assumed to create no change in noise level for construction.

As described in **Section 9.3.1: Construction Phase**, the Proposed Project will be built in phases. Construction phases are estimated to occur in 2026, 2036, 2046, 2060, and 2074. The 2026 construction phase noise impacts are estimated to be representative of all subsequent construction phases.

Select noise sensitive receptors were evaluated within the noise study area for the Proposed Project to represent estimated construction noise impacts. Representative noise receptors were identified at different locations along the existing roadway network and at different distances from the existing roadway network. The existing roadways including Hirst Road, Shamrock Road, Bodden Town Road, and Frank Sound Road were projected as the primary construction routes needed to access the Proposed Project construction areas. Construction routes are subject to change in detailed design based on location of materials, workers, and staging areas.

Based on the magnitude of workforce previously described, an estimated 200 commuter vehicles, 36 medium work and delivery vehicles, and 20 heavy equipment vehicles were added to the 2026 Future No-Build PM traffic counts in order to calculate a magnitude of change. **Table 9-11** shows the results of the construction noise impacts. The magnitude of construction noise is estimated to be within the Minor to Moderate range for noise sensitive receptors within the noise study area.

Table 9-11: Estimated Magnitude of Construction Noise Impacts

Representative Receptor	Distance to Source (ft)	Distance to Source (m)	2026 Future No-Build Noise Level (dBA)	Noise Level including Proposed Project Construction Vehicles (dBA)	Change in Noise Level (dBA)	Magnitude of Change
M02-54	15.7	4.8	69	71	2	Minor (≥ 1 and < 3)
M03-76	32.2	9.8	66	68	2	Minor (≥ 1 and < 3)
M03-159	52.8	16.1	57	61	4	Moderate (≥ 3 and < 5)
M05-18	54.5	16.6	65	66	1	Minor (≥ 1 and < 3)
M05-116	23.3	7.1	69	70	1	Minor (≥ 1 and < 3)
M05-242	79.7	24.3	62	63	1	Minor (≥ 1 and < 3)
M07-200	38.1	11.6	64	68	4	Moderate (≥ 3 and < 5)
M09-02	20.0	6.1	66	69	3	Moderate (≥ 3 and < 5)
M10-19	115.5	35.2	57	62	5	Moderate (≥ 3 and < 5)

9.3.1.2 Construction Vibration Impacts

Estimated construction-related vibrational impacts were evaluated consistent with the methodology in **Section 9.1.6: Constraints and Limitations**. The Future No-Build is assumed to require no new construction, and therefore, it is assumed to result in no construction vibrational impacts.

The estimated construction activity for the Proposed Project does not include activities such as pile driving and blasting, that are the primary causes of vibration impact. However, some of the estimated potential equipment can cause ground-borne vibration including dozers, drill rigs, and rollers, if vibratory rollers are used (**Table 9-9**). Of these machines, the vibratory roller has the highest magnitude of vibration, followed by the drill rig. Specific construction areas for the use of these potential machines are unknown at this stage. The use of vibratory rollers can be restricted in areas where sensitive structures are within a screening distance of construction activity. Similarly, once areas of drilling are established, a screening distance can be used to identify sensitive structures and mitigation or restrictions recommended, if necessary. Screening distances for vibratory rollers and drill rigs corresponding to the magnitude of vibration impact in LA-111 Table 3.33 were calculated and can be found in **Table 9-12**.

Table 9-12: Magnitude of Vibration Impact Screen Distances

Magnitude of Impact	Screening Distance for Vibratory Roller		Screening Distance for Drill Rig	
	(ft)	(m)	(ft)	(m)
Minor	75.5-170.6	23-52	42.7-95.1	13-29
Moderate	16.4-75.5	5-23	9.8-42.7	3-13
Major	<16.4	<5	<9.8	<3

Applying these screening distances to the entire Proposed Project LOD results in estimated vibration impacts in the Minor to Moderate range. It is recommended that the need for vibratory rollers, and areas of specific use for vibratory rollers and drill rigs, should be further reviewed during the detailed design and construction phases.

Table 9-13 provides a summary of the estimated construction phase noise and vibration impacts.

Table 9-13: Construction Phase Noise and Vibration Impacts Summary

Receptor / Resource / Impact Summary	Description / Potential Effect *(include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude	Sensitivity	Significance*
Construction noise	Temporary noise level increases due to construction equipment, delivery vehicles, and commuting crew members may be experienced by noise sensitive receptors within the identified noise study area. This effect has a high likelihood of occurrence and has been identified with a medium certainty.	Adverse, Short-Term, Local	Minor/ Moderate	All receptors identified within this evaluation were identified as sensitive to noise	Significant, since moderate magnitude of change is estimated for an approximately 2-year construction phase, during multiple phases of construction (2026, 2036, 2046, and 2060).
Construction vibration	Vibrations due to construction activities may reach levels of perception and annoyance to the general population in areas closest to the source. This effect has a medium likelihood of occurrence and has been identified with a low certainty.	Adverse, Short-Term, Local	Minor/ Moderate	All receptors identified within this evaluation were identified as sensitive to vibration	No significant impacts estimated; however, impacts are dependent upon later design stages.

*Qualitative rating of significance is not applicable for noise and vibration. Consistent with UK Department for Transport "Transport Analysis Guidance" noise impacts are quantitatively and monetarily assessed.

9.3.2 Operation Phase

Opening year (2026), and future years 2036, 2046, 2074-Low, 2074-Medium, and 2074-High traffic volumes, vehicle composition, and speeds were incorporated into the validated TNM v2.5 models to determine loudest hourly-equivalent traffic noise levels. Traffic data used in the modelling is included in **Appendix H.1: Traffic Data for Noise Analysis** and discussed in **Section 9.1.3: Incorporated Traffic Data Methodology**. See **Chapter 7: Transportation and Mobility** of this ES for additional information regarding the traffic volumes and analysis.

Roadway noise generation is dependent on three main factors: traffic volume, traffic speed, and traffic composition or vehicle type. Each of these varies at any given moment. The dominant noise sources vary by speed and by vehicle type (i.e., car vs. heavy truck). As shown in **Appendix H.1:**

Traffic Data for Noise Analysis, traffic projections differ greatly between Future No-Build 2026 and the Proposed Project for 2074. Although 2074 volumes are greater, average traffic speeds are projected to be higher in 2026. The combination of traffic speed and volume differs under each condition and year, creating a difference in the number of estimated noise impacts. An overview of traffic characteristics is provided in **Table 9-14**.

Table 9-14: Averaged Traffic Characteristics Within Noise Study Area

Characteristic	Future No-Build	Proposed Project
2026		
Total PM peak vehicular volume within study area	8,105 vehicles	8,646 vehicles
Average Speed	32 mph	36 mph
2036		
Total PM peak vehicular volume within study area	12,019 vehicles	12,376 vehicles
Average Speed	29 mph	36 mph
2046		
Total PM peak vehicular volume within study area	14,420 vehicles	15,170 vehicles
Average Speed	27 mph	35 mph
2074-Low		
Total PM peak vehicular volume within study area	17,246 vehicles	22,676 vehicles
Average Speed	26 mph	34 mph
2074-Medium		
Total PM peak vehicular volume within study area	20,331 vehicles	24,504 vehicles
Average Speed	23 mph	34 mph
2074-High		
Total PM peak vehicular volume within study area	41,326 vehicles	76,058 vehicles
Average Speed	14 mph	24 mph

Note: Vehicular composition does not vary between year or scenario.

The Future No-Build noise levels were predicted without the Proposed Project in place. The Proposed Project noise levels were predicted by accounting for the improvements described in **Chapter 6: Proposed Project – Engineering Features**.

The next step in the noise analysis was to determine if noise levels at the noise sensitive receptors would approach or exceed the identified impact levels. Noise levels at each modelled receptor for the modelled condition years are shown in **Appendix H.2: Predicted Noise Levels – Future No-Build** and **Appendix H.3: Predicted Noise Levels – Proposed Project**.

For the opening year noise evaluation, the 2026 Future No-Build condition is considered the baseline of comparison to the 2026 Proposed Project. Results of the traffic noise modelling in the opening year (2026) can be found in **Table 9-15**. The Proposed Project column depicts the number of receptors experiencing an increase in noise level (major, moderate, minor, negligible), no change, or decrease in noise level (major, moderate, minor, negligible) in year 2026 compared to the Future No-Build (i.e., Proposed Project number of receptors minus Future No-Build number of receptors).

For the 2026 Proposed Project, 889 noise receptors are projected to experience a noticeable increase in noise level (Major, Moderate, or Minor) and 452 noise receptors are projected to experience a noticeable decrease in noise level (Major, Moderate, or Minor). In addition, 94 noise receptors are projected to experience no substantial change in noise level (Negligible or No change).

Table 9-15: Estimated Magnitude of Change at Receptors Opening Year (2026)

Change in Noise Level (2026 Proposed Project minus 2026 N0-Build)		Number of Receptors Proposed Project
Increase in noise level, L_{A10}*	≥ 5 (Major)	385
	≥ 3 and < 5 (Moderate)	157
	≥ 1 and < 3 (Minor)	347
	< 1 (Negligible)	0
No change	0	94
Decrease in noise level, L_{A10}	< 1 (Negligible)	0
	≥ 1 and < 3 (Minor)	331
	≥ 3 and < 5 (Moderate)	79
	≥ 5 (Major)	42

* L_{A10} is the A-weighted sound level, in decibels, that is exceeded 10% of the measurement period

Results of the traffic noise modelling in the horizon year (2074) comparing the Proposed Project 2074 to the 2026 Future No-Build conditions can be found in **Table 9-16** (i.e., 2074 Proposed Project minus 2026 Future No-Build noise levels). For the Proposed Project 2074-Medium scenario, 963 noise receptors are projected to experience a noticeable increase in noise level (Major, Moderate, or Minor) and one noise receptor is projected to experience a noticeable decrease in noise level (Major, Moderate, or Minor). In addition, 471 noise receptors are projected to experience no change or a negligible change in noise level. A map depicting the projected year 2074 magnitude of change is provided in **Figure 9-5 through Figure 9-7**.

Table 9-16: Estimated Magnitude of Change at Receptors Horizon Year (2074)

Change in Noise Level (2074 Proposed Project minus 2026 N0-Build)		Number of Receptors		
		2074-Low	2074-Medium	2074-High
Increase in noise level, L_{A10}*	≥ 10 (Major)	337	329	669
	≥ 5 and < 10 (Moderate)	482	511	631
	≥ 3 and <5 (Minor)	175	123	128
	< 3 (Negligible)	307	279	7
No change	0	78	144	0
Decrease in noise level, L_{A10}	< 3 (Negligible)	55	48	0
	≥ 3 and <5 (Minor)	1	1	0
	≥ 5 and < 10 (Moderate)	0	0	0
	≥ 10 (Major)	0	0	0

* L_{A10} is the A-weighted sound level, in decibels, that is exceeded 10% of the measurement period

Figure 9-5: Proposed Project 2074-Low Scenario Magnitude of Change

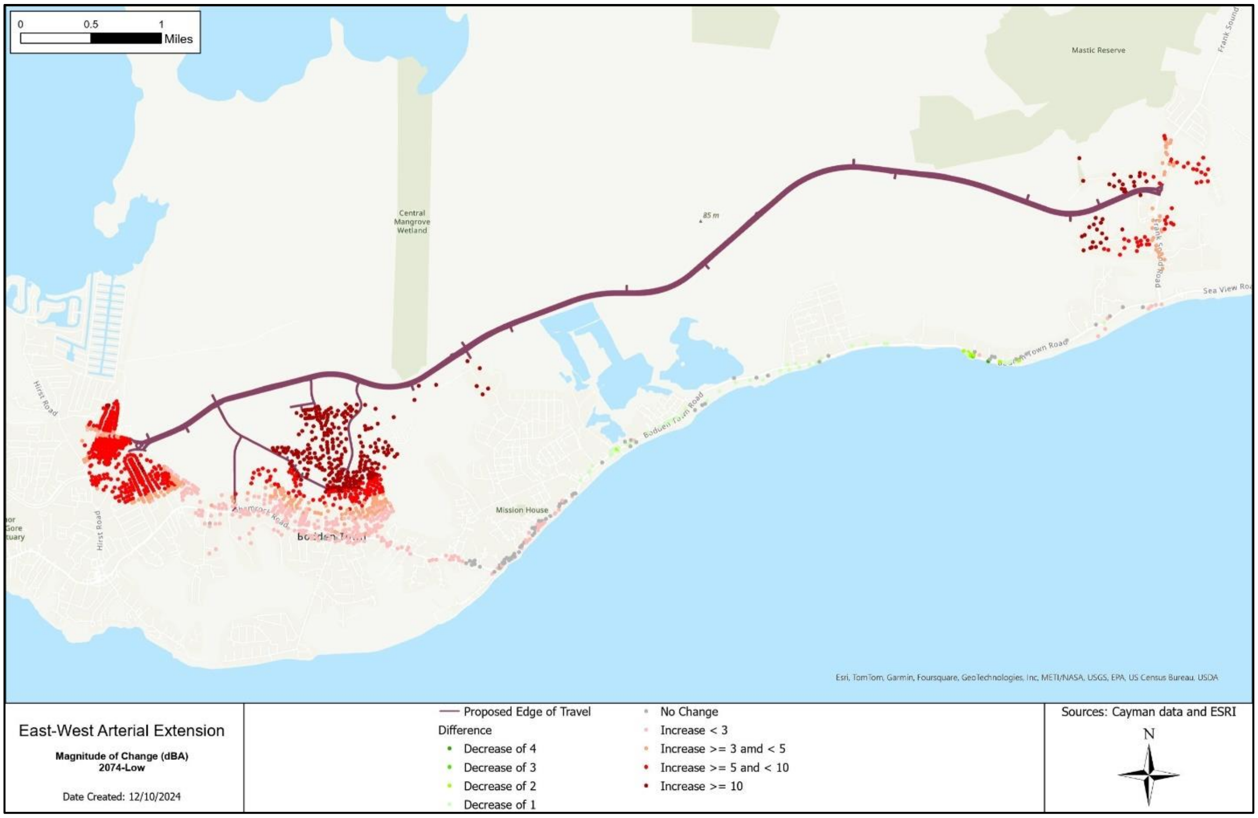


Figure 9-6: Proposed Project 2074-Medium Scenario Magnitude of Change

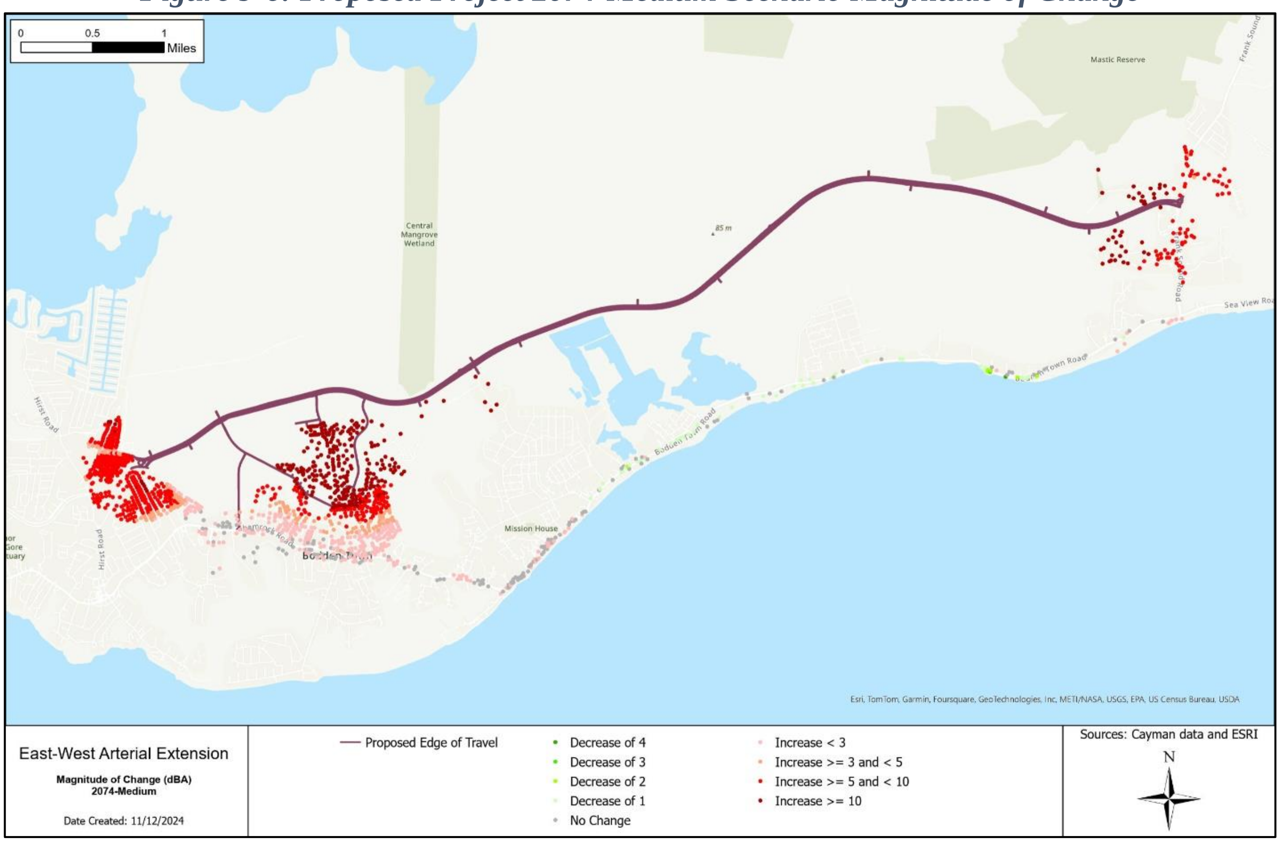
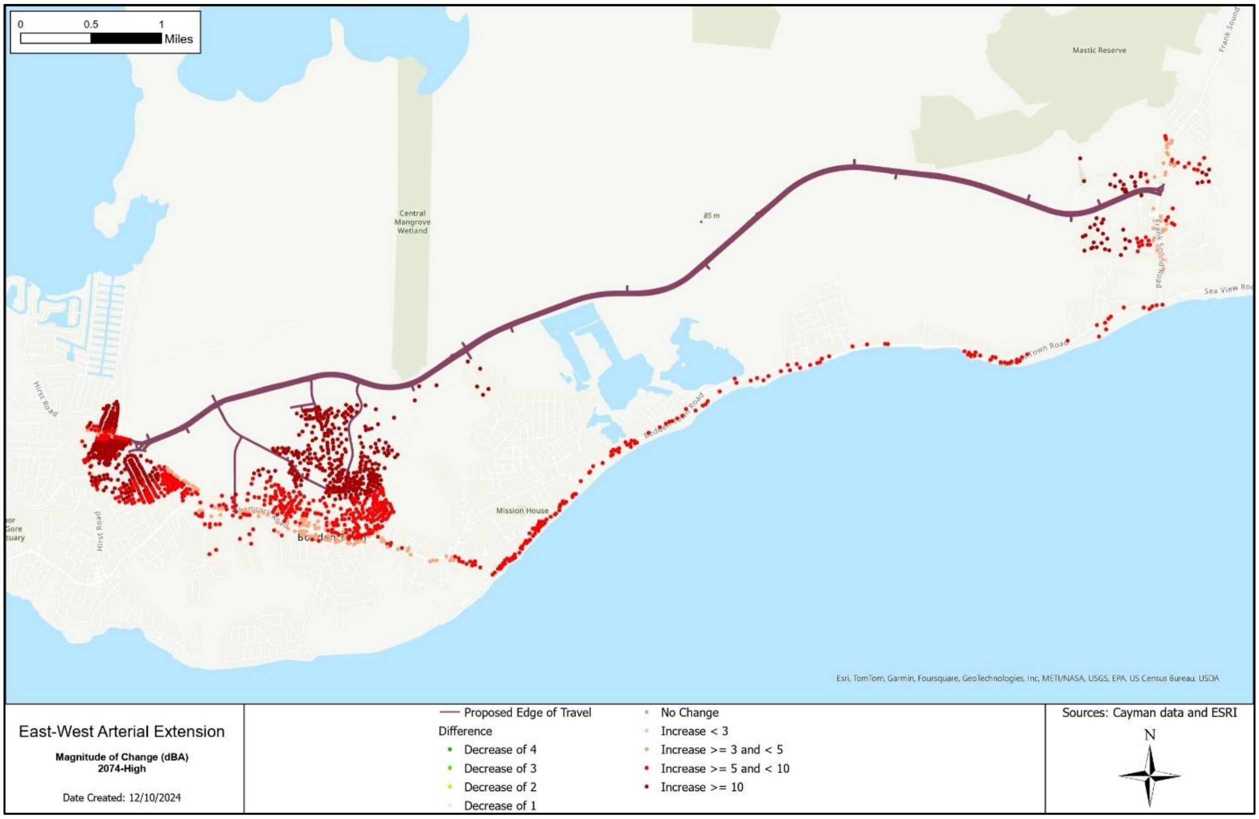


Figure 9-7: Proposed Project 2074-High Scenario Magnitude of Change



Results of the traffic noise modelling on receptors at or above the SOAEL threshold (68 dBA) can be found in **Table 9-17**. SOAEL is "the level above which significant adverse effects on health and quality of life occur" (DMRB). As noted in the ToR, the SOAEL threshold determines locations for the evaluation of noise mitigation measures.

In the opening year (2026), 82 noise sensitive receptors are projected to be at or above the SOAEL threshold. This number increases to 182 in 2036, 224 in 2046, and 279 in the 2074-Medium Scenario. An overview of the Proposed Project 2074 SOAEL impacts is provided in **Figure 9-8 through Figure 9-10** and a more detailed map is included within **Appendix H.4: Proposed Project 2074-Medium SOAEL Impact Mapping**.

Table 9-17: Noise Sensitive Receptors at or Above SOAEL (68 dBA)

Year	Proposed Project
2026	82
2036	182
2046	224
2074-Low	286
2074- Medium	279
2074-High	447

Figure 9-8: Proposed Project 2074- Low Scenario SOAEL (68 dBA) Impacts

Figure 9-9: Proposed Project 2074- Medium Scenario SOAEL (68 dBA) Impacts

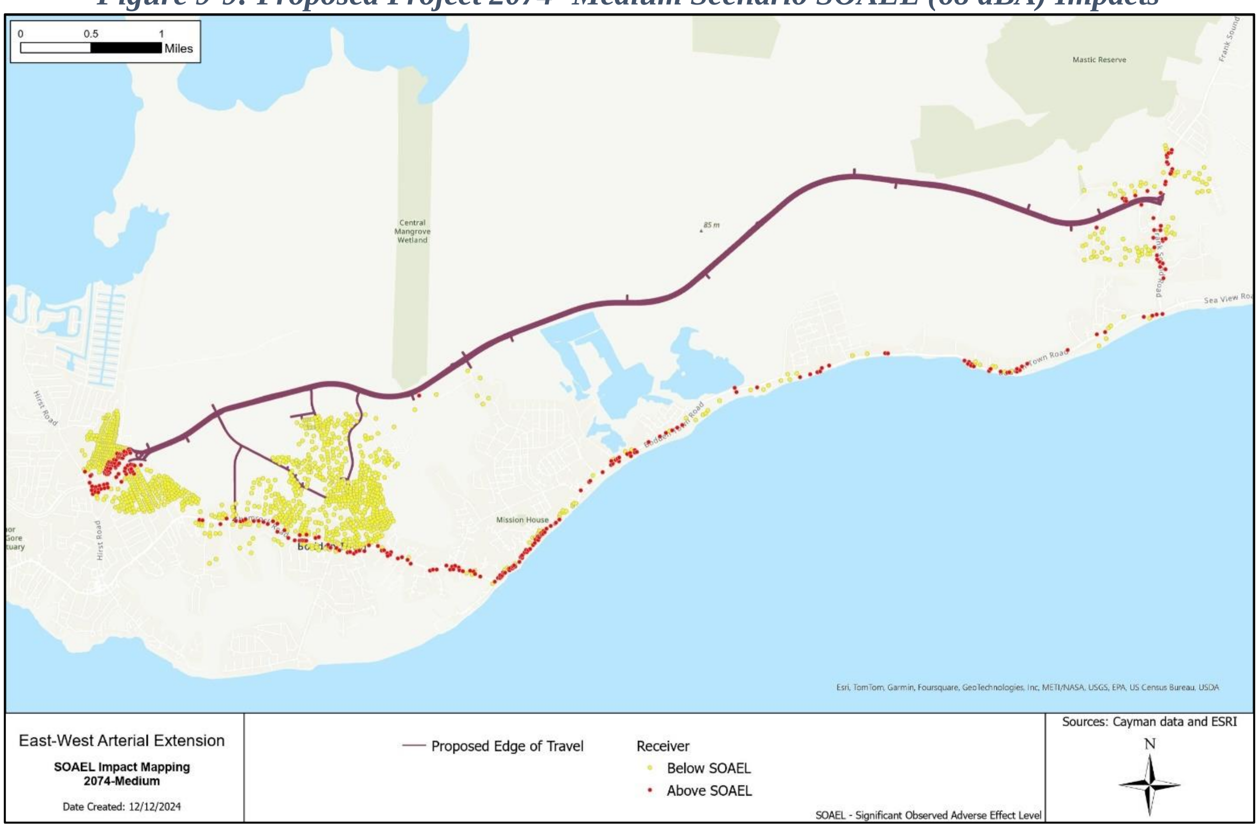
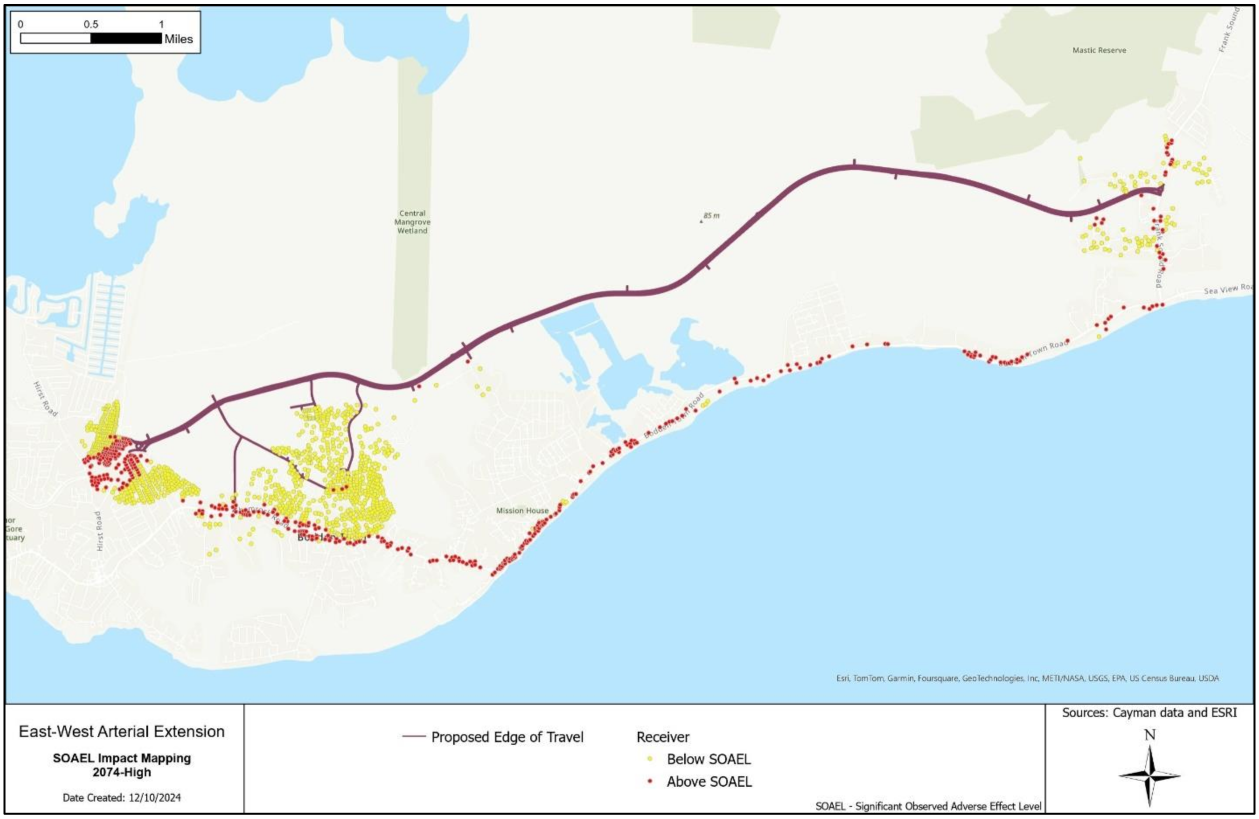


Figure 9-10: Proposed Project 2074- High Scenario SOAEL (68 dBA) Impacts



Assumes inclusion of Traffic Noise Barrier discussed in* ***Section 9.4.2: Operation Phase*

Table 9-18 provides a summary of the estimated operation phase noise impacts.

Table 9-18: Operation Phase Noise Impacts

Receptor / Resource / Impact Summary	**Description / Potential Effect** *(include likelihood and certainty)*	**Type / Temporal / Geographic**	**Magnitude**	**Sensitivity**	**Significance**
Operational noise	Operation of the Proposed Project would alter traffic patterns within the noise study area and alter resulting noise levels at identified sensitive receptors. Based on the traffic modelling completed for the Proposed Project, it would have an adverse impact (increase in noise level) to receptors adjacent to the new corridor. This effect has a high likelihood of occurrence and has been identified with a medium certainty. The CBA completed as part of the EIA includes monetisation of noise impacts utilising three 2074 population growth scenarios (Low, Medium, and High). This impact analysis represents the 2074-Medium Scenario.	Adverse, Long-Term, Local	Estimated long-term adverse receptor impacts include 329 Major, 511 Moderate, 123 Minor, and 471 Negligible/Neutral for the Proposed Project. A benefit (reduced noise level) is projected at 1 receptor.	All receptors identified within this evaluation were identified as sensitive to noise	279 noise sensitive receptors are projected to be at or above the SOAEL for the Proposed Project 2074-Medium Scenario.

*Qualitative rating of significance is not applicable for noise and vibration. Consistent with UK Department for Transport "Transport Analysis Guidance" noise impacts are quantitatively and monetarily assessed.

9.4 Mitigation Measures

The following section describes mitigation considerations for the noise and vibration impacts described in **Section 9.3: Project Impacts**. **Table 9-19** describes the characterizations used to evaluate the impacts and mitigation measures.

Table 9-19: Impact Analysis Factors

Characterisation	Description	Quantitative Measure or Definition of Qualitative Categories
Magnitude	The size or degree of the effects compared against baseline conditions or reference levels, and other applicable measurement parameters (i.e., standards, guidelines, objectives)	Categories are based on the DMRB LA 111 and shown in **Sections 9.1.4** and **9.1.5** above. Categories include: **Major |** dBA Change ≥ 10 **Moderate |** dBA Change ≥ 5 – < 10 **Minor |** dBA Change ≥ 3 – < 5 **Negligible |** dBA Change < 3
Geographic Extent	The geographic area over which the effects are likely to be measurable	**Limits of Disturbance (LOD) |** Occurs within the Proposed Project LOD **Outside Limits of Disturbance (OLOD) |** Occurs outside of the Proposed Project LOD, but within the identified Study Area
Timing	Considers when the environmental effect is expected to occur. Timing considerations are noted in the evaluation of the environmental effect, where applicable or relevant.	**Not Applicable (NA) |** Seasonal variations are not likely to change the effect **Applicable (A) |** Seasonal aspects may affect the outcome of the effect
Duration	The time period over which the effects are likely to last	**Short-Term (ST) |** The effect is reversible at the end of construction works **Medium-Term (MT) |** The effect is reversible within a defined length of time **Long-Term (LT) |** The effect is reversible over an extended length of time
Frequency	The rate of recurrence of the effects (or conditions causing the effect)	**Once (O) |** Effects occur once **Occasional (Oc) |** Effects that could occur randomly throughout the project lifetime **Regular (R) |** Effects can occur at regular intervals through construction and/or operation **Continuous (C) |** Effects are continuous throughout construction and operation
Reversibility	The degree to which the effects can or will be reversed (typically measured by the time it will take to restore the environmental attribute or feature)	**Reversible (R) |** The baseline conditions could recover to their standard after the construction works are completed **Partially Reversible (PR) |** Mitigation could return the baseline conditions **Not Reversible (NR) |** Mitigation cannot guarantee a return to baseline conditions

9.4.1 Construction Phase

While some of the estimated noise and vibration disturbances, caused by the construction of the Proposed Project to populated residential areas, may be inevitable given the inherently noisy operations associated with construction, it may be possible to control and minimise certain aspects of the projected construction noise and vibration effects through the use of reasonable (i.e., cost implications) and feasible (i.e., physically achievable) means.

Best practice noise mitigation techniques, as stated in the DMRB LA111, should include the following measures:

> *"1) training of site personnel to raise awareness of noise and nearby noise sensitive receptors;*
>
> *2) provision of information to the public on expected construction noise, including duration, especially to those likely to be exposed to moderate and major magnitude of effect."*

Both of these best practice techniques are recommended for consideration.

Additional noise mitigation measures, as stated in the DMRB LA111, for sources other than diversion routes may include:

> *"1) specification of the use of noise reduction construction methods, for example: specifying the use of rotary rather than driven piling;*
>
> *2) provision of measures to reduce the noise reaching noise sensitive receptors, for example: installation of temporary barriers;*
>
> *3) restriction of some activities to less sensitive times, for example: restricting piling activity to the daytime only;*
>
> *4) providing noise insulation to houses, or temporarily rehousing local residents."*

These additional construction noise mitigation measures are recommended to be further evaluated for consideration during the detailed design phase.

Best practice vibration mitigation techniques, as stated in the DMRB LA111, should include the following measures:

> *"1) selection of construction method and plan to minimise vibration generated;*
>
> *2) training of site personnel to raise awareness of vibration and nearby vibration sensitive receptors;*
>
> *3) provision of information to the public on expected construction vibration, including duration, especially to those likely to be exposed to moderate and major impacts."*

All three of these best practice techniques are recommended to be further evaluated for consideration during the detailed design phase.

Additional vibration mitigation measures, as stated in the DMRB LA111, may include:

> *"1) restrictions on construction method to reduce vibration;*
>
> *2) restrictions of some activities to less sensitive times, for example, restricting piling activity to the daytime only;*
>
> *3) temporarily rehousing local residents."*

These additional construction vibration mitigation measures are recommended to be further evaluated for consideration during the detailed design phase. **Table 9-20** provides a summary of the potential noise and vibration mitigation measures considered for the construction phase.

Table 9-20: Mitigation for Noise and Vibration during the Construction Phase Summary

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Noise Sensitive Receptors</td><td rowspan="2">Temporary noise level increases due to construction equipment, delivery vehicles, and commuting crew members may be experienced by noise sensitive receptors within the identified noise study area.</td><td rowspan="2">Best practice noise mitigation techniques including: 1) training of site personnel to raise awareness of noise and nearby noise sensitive receptors; 2) provision of information to the public on expected construction noise, including duration, especially to those likely to be exposed to moderate and major magnitude of effect.

Additional noise mitigation measures for consideration within Detailed Design: 1) specification of the use of noise reduction construction methods, for example: specifying the use of rotary rather than driven piling; 2) provision of measures to reduce the noise reaching noise sensitive receptors, for example: installation of temporary barriers; 3) restriction of some activities to less sensitive times, for example: restricting piling activity to the daytime only; 4) providing noise insulation to houses, or temporarily rehousing local residents.</td><td>Minor to Moderate</td><td>OLOD</td><td>NA</td><td>ST</td><td>R</td><td>R</td><td rowspan="2">Minor to Moderate, Localised noise impact</td><td rowspan="2">Significant- Best practice mitigation measures will be implemented, along with evaluation of additional mitigation measures as deemed necessary during Detailed Design. However, based on the anticipated length of construction per phase, and multiple phases of construction, the impacts constitute a significant effect.</td></tr>
<tr><td colspan="6">Construction noise impacts are projected to be minor to moderate in magnitude.

Construction noise impacts are anticipated to occur Outside the LOD.

Construction noise is temporary in nature, occurs at regular intervals, and is reversible once construction has ended.</td></tr>
</table>

Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Vibration Sensitive Receptors	Vibrations due to construction activities may reach levels of perception and annoyance to the general population in areas closest to the source.	Best practice vibration mitigation techniques including: 1) selection of construction method and plan to minimise vibration generated; 2) training of site personnel to raise awareness of vibration and nearby vibration sensitive receptors; 3) provision of information to the public on expected construction vibration, including duration, especially to those likely to be exposed to moderate and major impacts. Additional vibration mitigation measures for consideration within Detailed Design: 1) restrictions on construction method to reduce vibration; 2) restrictions of some activities to less sensitive times, for example, restricting piling activity to the daytime only; 3) temporarily rehousing local residents.	Minor to Moderate	OLOD	NA	ST	Oc	R	Minor, Localised vibration impact	Not Significant- with implementation of mitigation measures during detailed design and construction, potential vibration impacts are estimated to be minimal.
			Vibration impacts are projected to be minor in magnitude with the inclusion of mitigation measures. Construction vibration impacts are anticipated to occur Outside the LOD. Construction vibration is temporary in nature, occurs at occasional intervals, and is reversible once construction has ended.							

9.4.2 Operation Phase

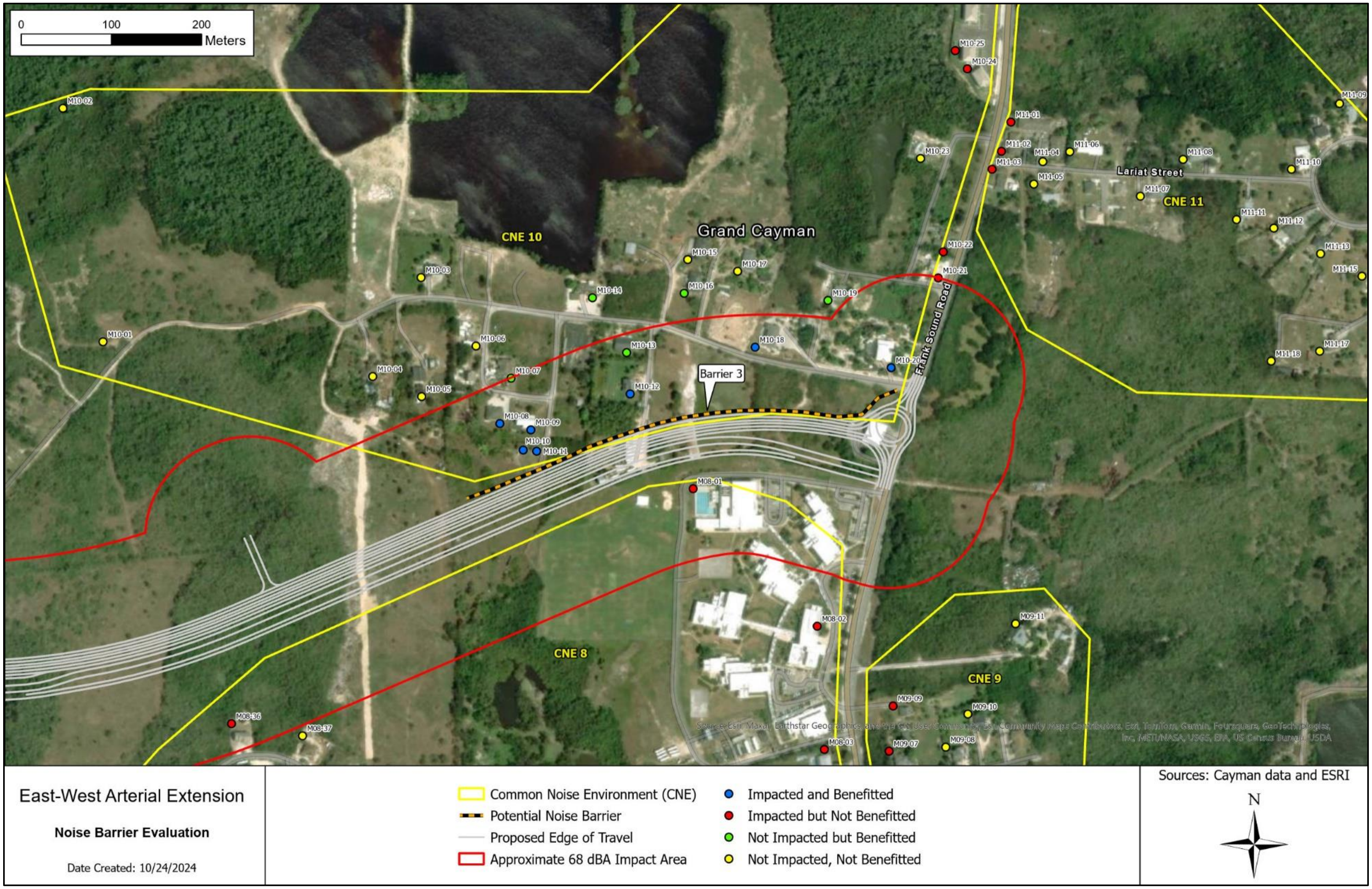
The following mitigation techniques are recommended for further evaluation and consideration during the detailed design phase, once more data becomes available (e.g., more detailed survey and hydrologic modelling), to aid in reducing the projected noise impacts of the operations phase. These mitigation measures include refinements to the horizontal and vertical roadway profiles, traffic speed control, and type of pavement materials. The refinements to the roadway profiles would include further evaluation of features such as reducing vertical elevation or shifting the horizontal alignment away from effected receptors within the corridor. Traffic speed control could include lowering speed limits near sensitive receptors (lower speeds usually results in lower noise levels); while pavement materials could include the utilisation of quieter road surfaces (durable open-graded, rubberized asphalt, or stone matrix asphalt mixtures).

Installation of traffic noise barriers can be an effective technique to mitigate projected noise impacts. The potential for a traffic noise barrier was evaluated at locations where the 2074-Medium scenario levels were at or above the SOAEL. Potential noise barrier locations were evaluated for both feasibility (i.e., physically achievable) and reasonableness (i.e., cost-effectiveness). At the time of this noise assessment, cost effectiveness criterion has not been established for the Cayman Islands.

The cost of traffic noise barriers can vary greatly dependent on type, size (height and length) location, materials availability, geo-technical conditions, drainage considerations, utility needs/relocation, ROW costs and other site-specific conditions. Based on available noise barrier pricing information, the U.S. island state of Hawaii has an estimated cost for noise barriers of \$50 per square foot (\$/SF). This cost is based on historic data available through the U.S. FHWA. This estimate only includes noise barrier material and installation costs, and any additional costs such as utility relocation, ROW acquisition, earthwork, etc. would need to be added in estimating total costs.

Locations along the Proposed Project corridor with identified SOAEL noise receptors were evaluated for the feasibility and reasonability of a potential traffic noise barrier. The most reasonable (cost-effective) location that was identified is located along the northern side of the Proposed Project beginning at the proposed intersection of Frank Sound Road and travelling to the west (**Figure 9-11**). This potential noise barrier has a length of approximately 1,657 ft (505 m) and an average height of 14.7 ft (4.5 m), resulting in an overall area of approximately 9,173 sq. ft (2,795 m^2). Based on the estimated cost per square ft of \$50 USD (CI\$42), the proposed noise barrier would cost approximately \$1,226,180 USD (CI\$1,030,403) for materials and installation. Note that possible additional costs previously described would increase this estimated amount.

Figure 9-11: Potential Noise Barrier Location



The results of this conceptual noise barrier analysis for the years 2026, 2036, 2046, and 2074 Low, Medium and High scenarios are summarized in **Table 9-21**. In examining the reasonableness (i.e., cost-effectiveness) of this noise barrier, it does not appear to be near cost-effective until 2074.

As previously noted, the Cayman Islands' do not have an established cost-effective reasonability threshold. However, based on the existing land use and the results of the noise analysis, a $1.5 Million USD (CI$1.3 Million) "Potential Noise Mitigation" line item was added to the estimated project costs (**Chapter 6: Proposed Project – Engineering Features**). It is recommended that this conceptual noise barrier be re-evaluated for feasibility and cost-effectiveness prior to the 2060 project construction phase. Based on the 2060 re-evaluation, the budgeted line item could be utilised for a noise barrier, or possible alternative noise reduction measures (e.g., road surfacing, home insulation) based on feasibility and cost-effectiveness.

In addition, as noted in the ToR, noise compatible land use planning is a possible means to avoid future traffic noise impacts. The compatibility of highways and neighbouring local areas is an essential consideration for continued growth.

For use in examining future land use, a SOAEL estimated noise level contour line was established for undeveloped areas along the corridor (**Appendix H.5: Approximate Noise Impact Area (SOAEL) for Undeveloped Lands**). This SOAEL noise contour line is estimated to occur approximately 360 ft (110 m) from the edge of the nearest travel lane along both sides of the Proposed Project. It is recommended that information from this noise analysis be shared with the Cayman Islands Department of Planning for their consideration should they choose to develop policies and/or ordinances to limit the growth of noise-sensitive land uses located adjacent to the Proposed Project.

Table 9-21: Noise Barrier Analysis

Analysis Year	Number of Benefited Receptors*	Noise Barrier Length (ft.)	Average Noise Barrier Height (ft.)	Square Footage (sf.)	Total sf. per benefit	Potential Cost per sq. ft (Assuming $50 USD**)	Potential Cost per sq. ft CI$	Cost per Benefitted Receptor USD	Cost per Benefited Receptor CI$	Cost Effective ***
2026	3	1,030	18.00	18,540	6,180	$927,000	$778,992	$309,000	$259,664	No
2036	4	1,377	16.00	22,032	5,508	$1,101,600	$925,714	$275,400	$231,429	No
2046	4	1,377	16.00	22,032	5,508	$1,101,600	$925,714	$275,400	$231,429	No
2074 Low	10	2,047	15.20	31,114	3,111	$1,555,720	$1,307,328	$155,572	$130,733	No
2074 Medium	12	1,657	14.80	24,524	2,044	$1,226,180	$1,030,403	$102,182	$85,867	No - Near Threshold
2074 High	16	2,047	15.20	31,114	1,945	$1,555,720	$1,307,328	$97,233	$81,708	**Yes**

**Receives at least a projected 5dBA decrease*

***Cost estimate based off of U.S. FHWA historical data for the state of Hawaii.*

****Costs and cost effectiveness threshold should be re-evaluated as part of the detailed design phase. Current cost effectiveness assumed a maximum of 2,000 sf. per benefited receptor.*

*****US Dollars have been converted from CI Dollars at a rate of $1.00 CI = $1.19 US; $0.84 CI = $1.00 US.*

Table 9-22: Mitigation for Noise and Vibration during the Operational Phase Summary

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Noise Sensitive Receptors</td><td rowspan="2">Operational noise: Change in noise level due to the operation of the proposed roadway corridor.</td><td rowspan="2">Design related mitigation measures for further consideration during the Detailed Design phase include alteration of the roadway alignment, traffic speed control, and pavement materials.

Traffic noise barriers were evaluated as part of the EIA and a $1.5 million “Potential Noise Mitigation” line item was included within the estimated project costs. Based on the 2060 re-evaluation, the “Potential Noise Mitigation” budget could be utilised for a noise barrier, or alternative noise reduction measures (e.g., road surfacing, home insulation) based on cost-effectiveness and public input.

As noted in the ToR, noise compatible land use planning is a possible means to avoid future traffic noise impacts. Recommend that the SOAEL estimated contour line in undeveloped areas be provided to the Cayman Islands Department of Planning.</td><td>Moderate</td><td>OLOD</td><td>NA</td><td>LT</td><td>C</td><td>PR</td><td rowspan="2">It is anticipated that a majority of the noise sensitive receptors at the SOAEL impact level will remain significantly impacted after the implementation of mitigation measures.</td><td rowspan="2">Significant - It is anticipated that a majority of the noise sensitive receptors at the SOAEL impact level will remain significantly impacted after the implementation of mitigation measures.</td></tr>
<tr><td colspan="6">Based on the magnitude of change for the Proposed Project 2074-Medium scenario (Table 9-17), the majority of receptors within the noise study area are predicted to experience a Major, Moderate, or Minor noise level increase in comparison to the Future No-Build 2026.

Operational noise impacts are anticipated to occur Outside the LOD.

The operational noise impacts are based on the long-term traffic data and projected long-term effect on sensitive noise receptors.

While operational noise impacts may vary based on time-of-day and forecasted versus actual population forecasts, the impacts are projected to be relatively continuous

While some mitigation measures can limit noise impact from the proposed project, no mitigation measures are projected to reach existing baseline conditions and therefore only partially reversible.</td></tr>
</table>

9.4.3 Summary of Noise and Vibration Mitigation Measures

As described within this chapter, the construction-related noise and vibration are both temporary in nature, and the primary mitigation measures recommended for consideration include education of the public and construction workers and time-of-day constraints. As also described in this chapter, operational noise impacts resulting from the Proposed Project can lead to significant effects to adjacent noise sensitive receptors. Based on a conceptual noise barrier analysis, one potential noise barrier location was identified for evaluation in the 2060 construction phase and is estimated at approximately $1.5 Million USD (CI$1.3 Million). Based on the 2060 re-evaluation of the potential noise barrier, the $1.5 Million USD (CI$1.3 Million) "Potential Noise Mitigation" line item included in the cost estimate could be utilised for a noise barrier, or possible alternative noise reduction measures (e.g., road surfacing, home insulation) based on feasibility and cost-effectiveness.

Additional information regarding implementation, responsibilities for implementation, any monitoring and reporting, and actions for non-compliance will be included as part of the separate EMP. Due to the phased development of the project, a review of the mitigation measures and design solutions will be continually evaluated during the design, construction, and operation phases to allow for successful mitigation.

10 Greenhouse Gas Emissions

As stated in the ToR, the Proposed Project is anticipated to require the removal of peat during construction, decreasing the amount of greenhouse gas (GHG) storage (specifically carbon storage); this would allow more GHG emissions to be released into the atmosphere. The main GHGs associated with peat removal are CO_2 and methane (CH_4).

The assessment of GHG emissions considered effects from operational traffic emissions, construction tailpipe emissions, habitat and peat removal, bulk materials, annual carbon sequestration loss, and the construction and operations of a proposed solar array. This assessment included a quantitative annual and aggregated emissions total associated with the construction of the Proposed Project. Operational GHG emissions based on expected traffic volumes and vehicle fleet was also quantitatively determined for both pre- and post-construction operations. Pre-construction included the expected GHG emissions for current traffic patterns, while post-construction consisted of the expected GHG emissions from traffic utilising the Proposed Project.

This GHG Emissions chapter of the ES covers the following:

- Describes the methodology for GHG assessments.
- Establishes Baseline Conditions within the Study Area.
- Identifies the potential benefits and adverse impacts due to the project, including construction and operation phases.
- Offers avoidance, minimisation, and mitigation considerations for the Proposed Project's potential negative GHG emission impacts.

This chapter assesses the effects of the Proposed Project described in **Chapter 6: Proposed Project – Engineering Features**. Baseline Conditions, which equate to Existing Conditions, were established to demonstrate the existing GHG emissions within the study area. The Future No-Build conditions are consistent with **Chapter 7: Transportation and Mobility** and were used as a basis of comparison with the Proposed Project to characterize the GHG emission impacts.

10.1 Assessment Methodology

This section describes the methodology used to assess GHG emissions during the EIA process. This methodology is compliant with the ToR and incorporates both Cayman Islands and international standards and practices, which are described in the following subsections.

10.1.1 Applicable Standards and Guidelines

Standards, guidance and draft documentation related to GHG emissions include:

- Cayman Public Health Law, 2002 Revision
- IFC Guidance Note 3, 2006
- Cayman Islands' Climate Change Policy, 2024
- UK National Highways: Introduction and General Requirements for Sustainable Development and Design (GG103), Revision 0, 2019
- Cayman Islands National Energy Policy 2017-2037
- Cayman Islands National Energy Policy 2024-2045
- UK National Highways Carbon Tool Guidance Version 2.5, 2022

While there is no Cayman Islands-specific GHG reporting threshold, for context, the U.S. Environmental Protection Agency (EPA) and the State of Florida determines that 25,000 metric tonnes (MT) of GHG emissions requires reporting to the agency, and 100,000 MT equates to a large or major source. For the purposes of this analysis, the GHG project significance threshold would be equivalent to the large source threshold (100,000 MT). This threshold provides a numerical comparison for Proposed Project emissions and their general impact.

10.1.2 Incorporated Traffic Data Methodology

Traffic data utilised within this ES was developed for the EWA EIA project as part of the Traffic evaluation. The traffic data contributed to multiple components within the EWA EIA studies including this GHG evaluation **(Appendix I.1 - Traffic Data for GHG Analysis)**. See **Chapter 7: Transportation and Mobility** for additional information regarding the traffic volumes and analysis.

10.1.3 Traffic Emissions Methodology

The traffic evaluation presents a baseline year of 2021, opening year of 2026, and horizon year of 2074 with intermediate years of 2036 and 2046. The opening year and intermediate years consisted of the Future No-Build and Proposed Project. The horizon year consisted of the Future No-Build, and the Proposed Project with three population variations (2074-Low, 2074-Medium/"core", and 2074-High).

EPA Motor Vehicle Emission Simulator (MOVES) 4.0.1 was implemented to establish potential GHG emissions by year and condition. MOVES requires several input parameters which include vehicle age distribution, fuel type, road segments (length, vehicle volume, average speed), vehicle type, distribution of vehicle type by segment, representative meteorological data and time span (i.e., weekdays, months of the year and hr/day). The data were applied using a combination of known project information and most representative default values.

The analysis included five vehicle types and assumed the use of the fuel types available within MOVES for each of the modelled years. Because MOVES is a U.S. model, assumptions had to be made for the Cayman Islands. The assumption within the ToR, was the utilisation of emissions at 15-20 years behind the U.S. emission standards. Since the publication of the ToR, the CIG began restricting the importation of vehicles more than seven years old and published the Cayman Islands National Energy Policy 2024-2045 with emission targets. With these importation restrictions and published policy in mind, and based on coordination with the NRA and EAB, a realistic yet conservative estimate on the vehicular fleet was established as listed for the EIA (**Table 10-1**):

- For Baseline year (2021) and Opening year (2026) Analysis Years, MOVES Year is assumed to be 20 years behind each analysis year – i.e., 2001 MOVES Year and 2006 MOVES Year, respectively.
- For 2036 Analysis Year, MOVES Year is assumed to be 10 years behind the analysis year – i.e., 2026 MOVES Year
- For 2046 Analysis Year, MOVES Year is assumed to be in line with the analysis year – i.e., 2046 MOVES Year

- For 2074 Analysis Year, MOVES Year is assumed to be in line with the analysis year – i.e., 2060 MOVES Year, projected to 2074

Therefore, in assessments of the baseline year of 2021 and anticipated opening year of 2026, MOVES applied emission characteristics from Monroe County, Florida across the five vehicle types for years 2001 and 2006, respectively. The analysis for intermediate year 2036 assumed to be only 10 years behind U.S. emission expectations (MOVES year is 2026). The 2046 analysis year would be equivalent to U.S. emissions. The expectation for horizon year 2074 is that Grand Cayman's fuel type distribution is anticipated to be equivalent to the U.S.; however, MOVES only allows evaluation out to year 2060. To accurately represent 2074 emissions, MOVES default values were evaluated for 2046 and 2060; the 15-year fuel type differentials by vehicle type from 2046 to 2060 were assumed to be equivalent to the fuel type differentials between 2060 and 2074. Specifically, the distribution of gasoline passenger cars was anticipated to decrease by 5.8%, while electric vehicles increase by 10.9% from 2046 to 2060. Thus, 2074 distribution of gas, electric, and other vehicles are assumed to shift by that same amount from the 2060 percentages. **Table 10-1** provides the estimated fuel distribution for each vehicle type by modelled year.

Table 10-1: Fuel Distribution by Model Year and Vehicle Type

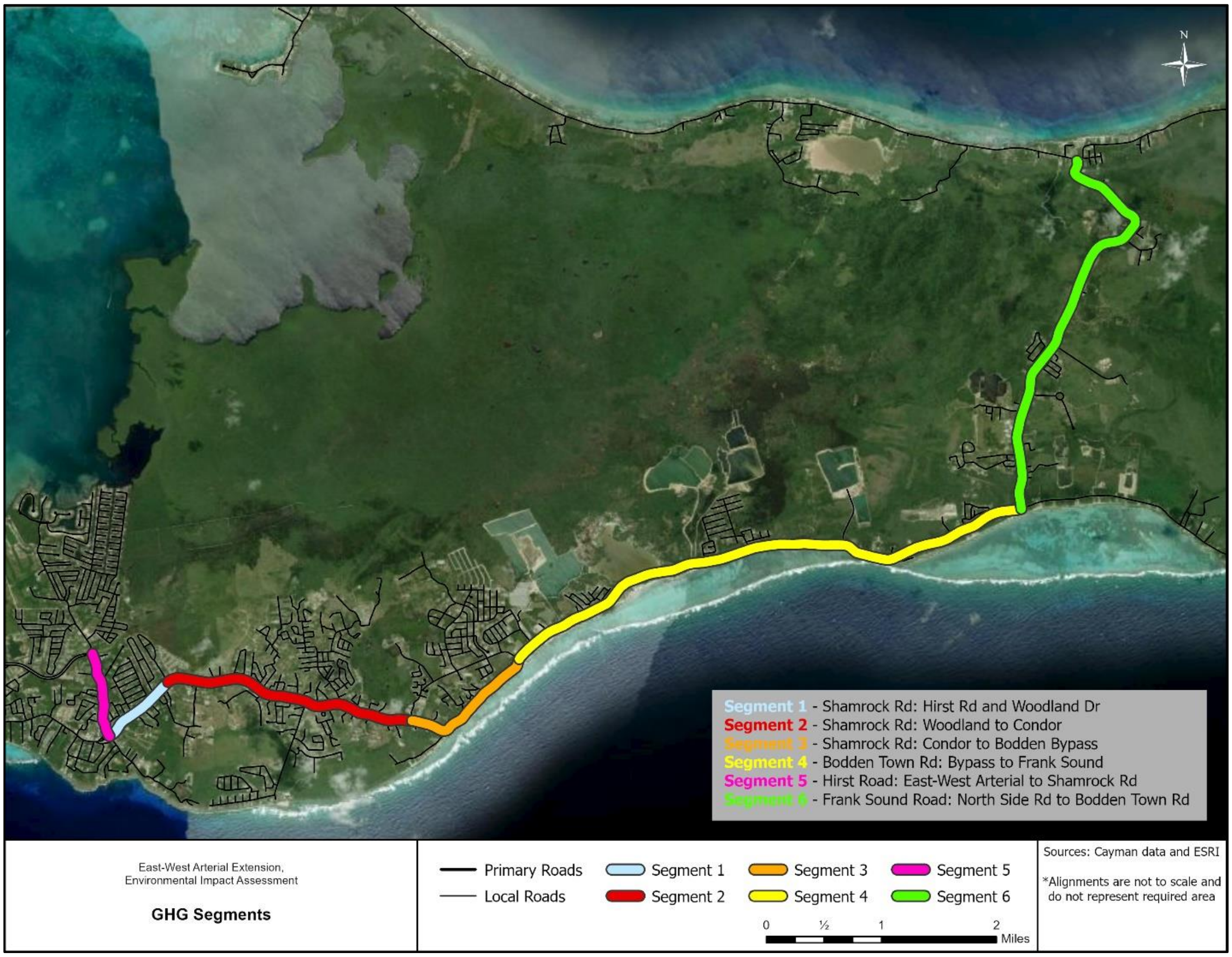
Fuel Distribution by Vehicle and Fuel Types																	
	Motorcycle	**Passenger Car**				**Transit Busses**				**Short Haul Truck**				**Combo Haul Truck**			
Year	**Gasoline**	**Gasoline**	**Diesel**	**Ethanol 85**	**Electric**	**Gasoline**	**Diesel**	**CNG**	**Electric**	**Gasoline**	**Diesel**	**CNG**	**Electric**	**Gasoline**	**Diesel**	**CNG**	**Electric**
2021 (MOVES year 2001)	100%	98.68%	0.34%	0.94%	0.04%	9.70%	80.98%	9.14%	0.18%	23.15%	76.77%	0.08%	0.00%	0.02%	99.98%	0.00%	0.00%
2026 (MOVES year 2006)	100%	95.74%	0.69%	3.55%	0.012%	17.32%	80.36%	2.32%	0.00%	20.47%	79.50%	0.03%	0.00%	0.00%	100%	0.00%	0.00%
2036 (MOVES year 2026)	100%	66.54%	0.01%	1.96%	31.49%	30.40%	58.69%	8.06%	2.84%	29.25%	65.56%	0.36%	4.39%	0.00%	98.80%	0.13%	1.08%
2046 (MOVES year 2046)	100%	63.14%	0.01%	1.89%	34.96%	30.49%	41.84%	10.14%	17.52%	25.27%	58.10%	0.37%	16.26%	0.00%	95.27%	0.15%	4.58%
2074 (MOVES year 2060)*	100%	55.85%	0.01%	1.32%	42.82%	34.42%	27.01%	21.05%	17.52%	26.27%	59.31%	0.61%	13.82%	0.00%	94.98%	0.44%	4.58%

*The Model Year is 2060, but with fuel characteristics adjusted to represent 2074

10.1.3.1 Road Segment Traffic Data

Traffic data was defined by road segments, road type, and length for the baseline and future years. The 2021 Baseline includes six segments: three along Shamrock Road (segments Hirst Road and Woodland Drive, Woodland to Condor Road, and Condor Road to Bodden Town Bypass), one along Bodden Town Road from the Bypass to Frank Sound, one along Hirst Road from EWA to Shamrock Road, and one along Frank Sound Road from North Side Road to Bodden Town Road (**Figure 10-1**). The Traffic evaluation used site day hourly data from June 2023 to establish a baseline of traffic volumes. A peak morning hour (6:00AM to 7:00AM) and a peak afternoon/evening hour (5:00PM to 6:00PM) was established. Volumes by vehicle type were determined for both AM and PM hours in two directions (northbound/southbound and eastbound/westbound) via the GCM. Traffic data incorporated into this evaluation can be found in **Appendix I.1 - Traffic Data for GHG Analysis**. Methodology of the incorporated traffic data can be in the previous section and in **Chapter 7: Transportation and Mobility**.

Figure 10-1: Roadway Segments – 2021 Baseline



For each road segment and peak hour, the MOVES model inputs included the aggregated total hourly volume, the segment length, and the average speed travelled along each segment. **Table 10-2** shows an example of the segment data from the 2021 Baseline. Following completion of the segment data, the distribution of each vehicle type by segment was calculated (See **Table 10-3**). These same data were determined for the Future No-Build and the Proposed Project. **Appendix I.1 - Traffic Data for GHG Analysis** provides information on the road segments for each modelled condition.

Table 10-2: Segment Data – Morning AM 2021 Baseline

Segment ID	Road Type	Segment Volume (veh/hr)	Segment Length (mi/km)	Segment Average Speed (mph/km/h)	Segment Description
1	Urban	1,595	0.68 (1.09)	29.5 (47.5)	Shamrock Rd: Hirst Rd and Woodland Dr
2	Urban	1,388	2.09 (3.36)	34.7 (55.8)	Shamrock Rd: Woodland to Condor
3	Urban	656	1.17 (1.88)	27.8 (44.7)	Shamrock Rd: Condor to Bodden Bypass
4	Urban	624	4.54 (7.31)	35.9 (57.8)	Bodden Town Rd: Bypass to Frank Sound
5	Urban	360	0.71 (1.14)	29.6 (47.6)	Hirst Road: EWA to Shamrock Rd
6	Urban	262	3.60 (5.79)	40.7 (65.5)	Frank Sound Road: North Side Rd to Bodden Town Rd

Table 10-3: Segment Data Vehicle Type Distribution – 2021 Baseline

Vehicle Type	1	2	3	4	5	6
	Morning 6:00AM to 7:00 AM					
Motorcycles	0.62%	0.87%	2.17%	0.21%	1.80%	3.12%
Passenger Cars	94.73%	92.34%	91.32%	93.25%	95.05%	87.31%
Transit Buses	1.24%	1.65%	0.39%	0.78%	0.63%	1.27%
Short Haul Truck	2.80%	4.20%	4.84%	5.45%	1.57%	7.45%
Combo Haul Truck	0.61%	0.94%	1.28%	0.32%	0.95%	0.85
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	1	2	3	4	5	6
	Afternoon/Evening 5:00PM to 6:00PM					
Motorcycles	0.93%	1.47%	1.02%	1.59%	4.52%	1.28%
Passenger Cars	88.95%	92.43%	90.87%	92.47%	91.55%	92.50%
Transit Buses	6.32%	1.78%	1.15%	0.22%	1.47%	1.51%
Short Haul Truck	2.00%	3.34%	6.37%	4.79%	1.52%	4.71%
Combo Haul Truck	1.80%	0.98%	0.58%	0.93%	0.95%	0.00%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

10.1.3.2 Intersection Traffic Data

In addition to the general road segments, the traffic analysis included potential emissions from four intersections. The four representative worst-case intersections were selected from the heaviest trafficked locations along the EWA as determined by the GCM. This correlated to mostly the western end of the arterial and Agricola Dr Connector Roundabout. Corresponding emissions from the four intersections were determined via MOVES. To account for the intersections within the project area a static multiplier was applied for each analysis year. For example, the No-Build comprised 13 total intersections; the MOVES intersection results were multiplied by 3.25 or 13/4.

Approach volumes were determined for each cardinal direction (north, east, south, and west) and each possible movement manoeuvre (U-turn, left turn, right turn, and through). This analysis generated 16 volume determinations per intersection or 64 in total for the four intersections. The selected intersections varied by year and condition. The four selected for the 2021 Baseline were located along Shamrock Road at Woodland Drive, Agricola Drive, Brightview Drive/Calla Lilly Drive and Beach Bay Road as they were projected to have the highest traffic volumes. The AM/PM peak hour volumes and approach speeds were determined for these intersections and movement manoeuvres via the GCM. Each potential intersection/manoeuvre combination was input into MOVES as an individual segment such as those shown in **Table 10-4**. In addition, the vehicle distribution percentages were applied uniformly for the intersections/manoeuvre combinations based on the average value of the road segments by type for the year evaluated. As an example, the average distribution for anticipated motorcycles amongst the segments in **Table 10-3** between 6:00AM and 7:00AM is 1.47%; therefore the 64 intersections/manoeuvres were allocated 1.47% motorcycles for the AM peak hour during 2021 Baseline.

The approach length of the intersection segments was defined uniformly as well to maintain consistency. The U-turn segments were set to 100 ft (30.5 m); both left and right turns were set to 200 ft (61.0 m), and the through lanes were set to 400 ft (121.9 m). Overall, the 2021 Baseline and Future No-Build consider a total of 13 intersections.

The Proposed Project intersection methodology again assumed the four most volume-impacted intersections, but one was a roundabout and the other three were partial access left-in/left-out intersections. Additionally, due to U-turns added to the Proposed Project, the two heaviest travelled U-turns were also modelled. Future year 2026 included one roundabout (EWA at Agricola Dr. Connector), three left-in/left-out access points to the south (Lookout Road, Will T Connector #1 and Will T Connector #2) and two eastbound U-turns (one between the Will T Connector access points and the other east of Lookout Road). Future year 2036 through 2074 analysed the same number of roundabouts and U-Turns as 2026; however, the number of access points increased to five as the northern access points were added at Lookout Road and Will T Connector #1.

The approach lengths of the various segments were established through the conceptual engineering design process and were applied uniformly across the three segment types. Refer to **Table 10-4** for details. The Proposed Project design for the years analysed included two total roundabouts (one on either end of the EWA; at Agricola Drive Connector and at Frank Sound Road) and seven U-Turns along the Proposed Project. The total number of intersections was 10 in 2026 and 17 for the other years analysed. As described in **Section 10.3.2: Operation Phase**, the modelled intersections/manoeuvres results incorporated a multiplier to reflect total number throughout the full length of the Proposed Project. For example, the model roundabout impact of Agricola Drive Connector was multiplied by 2 to account for the eastern roundabout.

Table 10-4: Proposed Project Approach Lengths

Segment Type	Manoeuvre	Segment Length ft (m)
Roundabout	Through	642.0 (195.7)
	U-Turn	996.0 (303.6)
	Eastbound Left turn	315.0 (96)
	Eastbound Right turn	656.0 (199.9)
	Westbound Left turn	656.0 (199.9)
	Westbound Right turn	315.0 (96)
	Northbound Left turn	315.0 (96)
	Northbound Right turn	656.0 (199.9)
	Southbound Left turn	315.0 (96)
	Southbound Right turn	656.0 (199.9)
Intersection	Through	400.0 (121.9)
	Westbound Left turn (left out)	114.0 (34.7)
	Southbound Left turn/Northbound Left turn (left in)	398.0 (121.3)
	Eastbound Right turn	339.0 (103.3)
U-Turns	Through	400.0 (121.9)
	Turn	420.0 (128)

10.1.4 Construction Tailpipe Methodology

The construction assumptions were estimated based on available conceptual design information prepared for the Proposed Project (see **Chapter 6: Proposed Project – Engineering Features** for conceptual design and phasing), coordination with the NRA on equipment availability, and subject to change in later detailed design phases, outside of this EIA. Conservative estimates were utilised where appropriate.

The construction equipment emissions factors were established using the U.S. EPA mobile source MOVES model version 4.0.1. The NONROAD component of the model was applied for diesel fuel construction equipment. A general list of equipment likely to be used for road construction was developed as shown in **Table 10-5** and applied for this analysis. Additionally, it was also assumed that delivery vehicles and worker commuter vehicles would be occurring during the anticipated construction phases (2026, 2036, 2046, 2060, and 2074).

Table 10-5: Typical Construction Equipment List

Road Construction Equipment Type	Commuter/Delivery Vehicles
Pavers	Gasoline Passenger Car
Rollers	Gasoline Passenger Truck
Excavators	Diesel Short Haul Truck
Graders	
Tractors/Loaders/Backhoes	
Crawler Tractor/Dozers	
Dumpers/Tenders	
Cranes	
Bore/Drill Rigs	
Rough Terrain Forklifts	
Surfacing Equipment	

MOVES NONROAD construction emission methodology is consistent with **Appendix E - Shortlist [Alternatives] Evaluation: Attachment I – Greenhouse Gas – Assessment of Alternatives** and updated to match the phasing and vehicular fleets shown in **Table 10-1**.

The estimated months of construction by phase, crew size, workdays, and delivery truck trips per day were established through coordination with the EWA EIA engineering team (**Table 10-6)**. It was also assumed that each worker would utilise one personal vehicle to travel to and from the work site. Material delivery operations were estimated to utilise a dedicated fleet of 10-20 delivery vehicles (trucks), with daily delivery truck trips ranging from approximately 46 to 333 depending on anticipated construction phase year at this conceptual design level; these assumptions are subject to change based on the detailed design phase outside of this EIA. The MOVES model years and corresponding analysis years for commuting and delivery vehicles are consistent with **Table 10-1**.

Table 10-6: Estimated Potential Commuting and Delivery Vehicles

Year	Estimated Months of Construction for Phase	Estimated Crew Size (Commuting Vehicles)	Estimated Workdays	Estimated Delivery Truck Trips per Day
2026	24	200	697	333
2036	24	200	697	218
2046	24	200	557	129
2060	24	200	557	124
2074	12	200	279	46

10.1.5 Habitat and Peat Methodology

GHG emissions resulting from the removal/excavation of biomass and organic soils (i.e., peat) were calculated for the Proposed Project following Intergovernmental Panel on Climate Change (IPCC) guidelines (IPCC, 2006; IPCC, 2014). This methodology conservatively assumes the biomass and peat removed during construction are disposed of under aerobic conditions and the carbon is immediately emitted as CO_2. No biomass and peat would be removed as part of the

Future No-Build and, therefore, do not apply to IPCC guidelines and equations (i.e., GHG emissions from biomass and peat removal are set to zero).

The approach for estimating changes in carbon stocks within the LOD differed between mangrove and non-mangrove habitat types and carbon pools (e.g., biomass, soil). Biomass carbon stocks concern woody and herbaceous vegetation across various habitat types classified through geospatial analysis. Soil carbon stocks, in contrast, concern peat deposits spread across the entire LOD for the Proposed Project. Additionally, peat data was volumetric, as opposed to geospatial. Method deviations, assumptions, and calculations for each carbon pool are detailed in the following subsections.

See **Appendix E - Shortlist [Alternatives] Evaluation: Attachment I – Greenhouse Gas – Assessment of Alternatives** for additional details regarding the habitat and peat removal methodology.

10.1.6 Bulk Material Methodology

For the Proposed Project, volumes for bulk material, pavement markings, light poles, excavation materials, and items such as bus stop shelters, and traffic signals were estimated for either new construction or rehabilitation and resurfacing for each of the years 2026, 2036, 2046, and 2060. Total usage of asphalt, concrete, soil, rock, and kerb was applied along with appropriate emission factors as defined by the UK National Highway Carbon Tool (UKNH 2023). This is a carbon calculation tool applied for operational, construction, and maintenance activities for UK national highway projects. The tool incorporates factors derived from the Bath Inventory of Carbon and Energy Version 3. For the purposes of this assessment, the Bath Inventory of Carbon and Energy was used to ensure representative factors were applied for each material type. For one material, non-woven geotextile, an emission factor from a study published in May of 2021 titled, "Assessment of Embodied Carbon for Geogrid-Reinforced Flexible Pavements" (Goud and Umashankar, 2022) was utilised. The value from this study was specific to non-woven geotextiles and was slightly higher than the value for polypropylene geotextile/matting from the UK National Highway Carbon Tool (2.665 tCO2e/t versus 2.54 tCO2e/t)[1].

Emissions are established on an input unit from a given material and CO_2e factor is applied. For example, the Bath Inventory of Carbon and Energy states that asphalt has a factor of 0.055 MT CO_2e per MT of asphalt (tCO_2e/t). Additionally, the Carbon tool utilises density (tonnes/ m^3) for various materials via the Bath Inventory Version 2.0.

Material totals were largely determined in either square yards, linear feet, or cubic yards (yd^3). Because the emission factors are in tCO_2e/t material, the total volumes were calculated. For example, compacted asphalt with a depth of 3.5 in (88.9 mm) is applied for new road construction. This allows for a volume to be established and converted to cubic metres (m^3) to correlate with known densities (2.3 tonnes/m^3 for asphalt). Emissions are then calculated for both new construction and maintenance through the end of year 2074. Some materials were provided as a count of the number of each, such as concrete pipe end sections, light poles, and pavement markings. For concrete end pipes a representative weight (lbs) per item was located and utilised.

[1] Carbon dioxide equivalent (CO_2e)

The weight in pounds was converted to tons and multiplied by the number of items in order to estimate the tons of material, which was then multiplied by the emission factor. For pavement markings, an estimated volume of material was calculated based on design assumptions. The calculated volume was multiplied by the count of pavement markings provided and the density of the material to obtain the tons of material. The tons of material were then multiplied by the appropriate emission factor. See **Appendix I.2 – Bulk Materials GHG Analysis** for material quantities. Additional details regarding quantification of bulk materials can be found in **Chapter 6: Proposed Project – Engineering Features**. Calculations were completed for each material and item for each year including 2026, 2036, 2046, 2060, and the full lifetime.

There are also a few materials that required specific calculation methodologies. These include pavement markings, tack coating, concrete barriers, guard rails, bus stop shelters, traffic signals, and attenuators. Additionally, the Carbon Tool applies some conversions directly related to the input units. An example specifically applied for this analysis was kerb (precast concrete 125x150mm) of 0.0431MT concrete/linear metre. This allows for conversion from known linear distance per year of concrete, an assumed size of precast concrete and known density of concrete. The Carbon Tool emission factor along with the conversion factor allows estimated GHG emissions to be determined from the known linear length of kerb to be used per year. Similar conversations were established and include within **Appendix I.2 – Bulk Materials GHG Analysis.**

There were three categories of bulk materials provided as counts (number of each item to be used within each year) that represented items that incorporated multiple materials. These three categories were bus stop shelters, traffic signals, and attenuators. The first step to estimating emissions from these items was to break out the parts of each item and identify the material used for each part. For example, a bus stop shelter would include vertical structural beams, a structural beam for the roof, roof panels, back and side wall panels, and a bench. The vertical and roof structural beams would likely be made of structural steel, the roof panels likely made of aluminium sheet, the side and back walls likely made of safety glass, and the bench likely made of cast aluminium. A count of each of these individual parts per overall bus stop shelter item was estimated, and then a volume for each part was calculated based on assumed design inputs. Once these steps were completed, the tons of material could be calculated based on the overall material volume and material density, and then multiplied by the emission factor for each specific material. See **Appendix I.2 – Bulk Materials GHG Analysis** for these calculations and results.

10.1.7 Annual Carbon Sequestration Loss

Annual carbon sequestration loss was calculated based on the 2020 Cayman Islands Ecosystem Accounting (Economics for the Environment Consultancy Ltd (EFTEC) & Joint Nature Conservation Committee, 2022). See **Section 10.3.2.1** of this chapter for further discussion as well as **Chapter 13: Terrestrial Ecology** for additional details regarding the habitat and peat removal methodology.

10.1.8 Solar Array

A proposed solar array feature was included in an overall CBA completed as part of the EWA Extension EIA to determine the economic efficiency of putting in a six-mi (9.7-km) canopy of PV solar panels along the Proposed Project EWA corridor; this proposed feature is intended to provide shade for the micromobility and sidewalk paths as well as provide electricity generation. Lifetime GHG emissions savings were estimated as part of this CBA and further described in **Section 10.3.2.2** of this chapter; additional explanation and details regarding this preliminary solar array assessment methodology can be found in **Chapter 16: Cost-Benefit Analysis** and **Appendix E – Shortlist [Alternatives] Evaluation: Attachment J – Cost-Benefit Analysis – Assessment of Alternatives**.

Details regarding the solar array and visualizations can be found in **Chapter 6: Proposed Project – Engineering Features**.

10.1.9 Constraints and Limitations

The evaluation of GHG emissions is primary based on data inputs from the traffic, engineering, and terrestrial ecology disciplines. Constraints and limitations for those disciplines can be found in their respective chapters, as referenced. Constraints and limitations applicable to the GHG evaluation include:

- Lack of Cayman Islands specific GHG reporting threshold
- Use of Florida-related MOVES and default input data as surrogate for Cayman Islands
- Any limitations noted within referenced data source chapters (**Chapter 6: Proposed Project – Engineering Features**, **Chapter 7: Transportation and Mobility**, and **Chapter 13: Terrestrial Ecology**)

10.2 Baseline Conditions

Baseline Conditions for GHG emissions included review of GHG policy, habitat data, and peat data. Additional Baseline Conditions information can be found in the **Appendix E - Shortlist [Alternatives] Evaluation: Attachment I – Greenhouse Gas – Assessment of Alternatives**.

10.2.1 GHG Emissions and Policy

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 connected to global warming, are continuing to increase at world levels despite numerous climate change mitigation agreements. 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, GHG emissions are reported annually by the DoE to Aether Consulting in the UK for electricity generation and fuel consumption. Data is also collected and submitted to Aether Consulting in the UK on solvent use, waste management, mobile machinery, aircraft and air transport, shipping, and agriculture and forestry.

The Aether Consulting data are broken down into eight general categories including residential, industrial processes, agriculture, land use/land use change and forestry, water management, business, transportation, and energy supply which are shown in **Figure 10-2** from the years 1990-2022 (Szanto, 2024). GHG emissions do not have as much of a direct effect on individual body pathways (i.e., respiratory, cardiovascular systems) in the short term because the body can handle limited exposures, although they have been found to influence the body through chronic exposure (Naiyer and Abbas 2022). Additionally, GHG would create overall changes in climate over a prolonged period.

On April 16, 2024, the Cayman Islands National Climate Change Committee issued a draft Climate Change Policy (Ministry of Sustainability and Climate Resiliency 2024), which is undergoing revisions and updates. The updated policy's goals are to be incorporated into the EIA process, if available. The 2024 policy outlines a series of goals and principles which include:

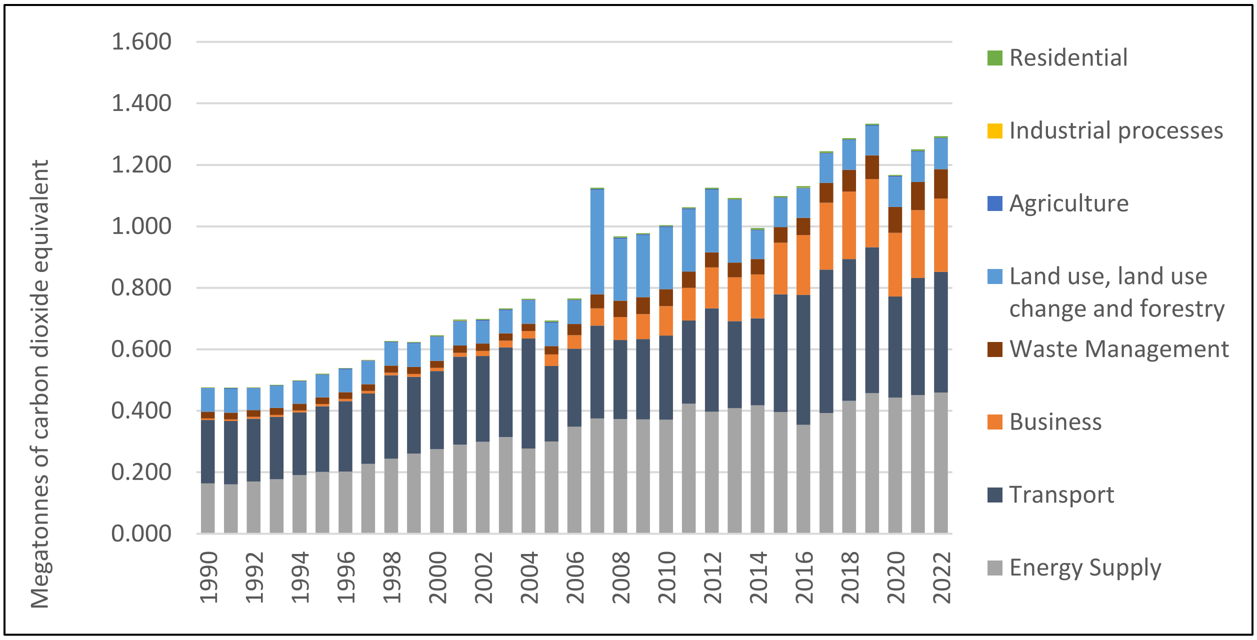
- Public Participation and Collaboration
- Implementation of Best Available Science and Technology
- Reduce vulnerability and enhance resiliency to climate change
- Promote sustainable, low or zero carbon economic activity
- Establish a governance framework for climate action which is future-focused, fair to all, accountable and transparent
- Resilient Infrastructure Networks

Additionally, the Cayman Islands National Energy Policy Unit (NEP) developed the National Energy Policy 2024-2045 (NEP, 2024). The new policy identified four primary goals each supported with by strategies over seven critical sectors such as electricity, transportation, public awareness/education and Climate Change. Goal #1 is geared toward knowledge and education which promotes a more informed community. Goal #2 focuses on innovation and advocates for the Cayman Islands to be a leader in sustainable energy solutions. GHG impacts are directly related to Goal #3, Energy Security. The goal is to expand renewable energy usage from 3% now to 100% of total energy generation by 2045.

As of 2014, the Cayman Islands produced 12.3 metric tons of CO_2e [2] per capita. The 2030 goal was to reduce that to 4.8 metric tons of CO_2e per capita. Updated targets along with 100% renewable energy by 2045 include: new vehicle sales and imports to 30% electric by 2030 and 100% electric by 2045. This correlates to a GHG emissions reduction from ground transportation of 90% by 2045 compared to 2019 levels (NEP, 2024).

[2] Note that CO_2e is a mathematical approach that applies global warming potential values for each GHG, which were developed to allow for direct comparisons of global warming impacts of varying gases. For example, CO_2 has a multiplier or potential of 1 while methane has a potential of 25, meaning methane is 25 times more impactful from a warming perspective.

Figure 10-2: Annual Greenhouse Gas Emissions by Sector in the Cayman Islands (1990-2022)



Source: Szanto, 2024

10.2.2 Habitat Data

Country-specific (Childs et al., 2015) and IPCC (2006; 2019) default data was sourced to estimate biomass carbon stocks for the various habitats across Grand Cayman anticipated to be disturbed by the Proposed Project. For mangroves, Childs et al. (2015) estimated above- and below-ground biomass carbon stocks for inland mangrove habitats across the CMW on Grand Cayman, using field sampling, species-specific allometry (Smith and Wheelan, 2006; Komiyama et al., 2005) and carbon fractions. IPCC default biomass estimates, root-shoot ratios (to estimate below-ground biomass) and carbon fractions were applied to the other habitats encompassed by this analysis (IPCC, 2006; IPCC; 2019). Equation 4.4 (IPCC, 2014) was modified to accommodate mangrove data (Childs et al., 2015) and estimate the loss of biomass carbon stocks within mangrove habitats for the Proposed Project.

Biomass stock loss for other (i.e., non-mangrove) habitats was estimated using a modified version of Equation 2.14 (IPCC, 2006) supplied with IPCC default values (IPCC, 2006; IPCC, 2019) specific to each habitat type included in the analysis.

A summary of parameters used in Equation 4.4 (IPCC, 2014) and Equation 2.14 (IPCC, 2006) for habitat types encompassed in this assessment are listed in **Table 10-7**. See **Appendix E - Shortlist [Alternatives] Evaluation: Attachment I – Greenhouse Gas – Assessment of Alternatives** for additional details regarding the habitat removal calculations.

Table 10-7: Habitat Biomass Parameters

Habitat	Above-ground biomass (AGB)	Below-ground biomass (BGB)	Root-shoot ratio (*R*)	Carbon fraction (*CF*)
	t.d.m. ha^{-1}	t.d.m. ha^{-1}		
Mangroves	102.99 (Childs et al., 2015)	58.58 (Childs et al., 2015)	-	AGB: 0.48 BGB: 0.39 (Childs et al., 2015)
Tropical Moist Deciduous Forest (Older Secondary)	131 (IPCC, 2019)	37.20*	0.284 (IPCC, 2019)	0.47 (IPCC, 2006)
Tropical Moist Deciduous Forest (Younger Secondary)	55.7 (IPCC, 2019)	15.85*	0.2845 (IPCC, 2019)	0.47 (IPCC, 2006)
Tropical Moist Grassland	6.20 (IPCC, 2006)	9.92*	1.6 (IPCC, 2006)	0.47 (IPCC, 2006)

* Calculated as [*AGB* x *R*]. t.d.m.ha-1 equates to MT of dry matter per hectare.

Mangrove biomass estimates are also assumed to include dead trees. However, litter was assumed *de minimis* (i.e., negligible) and excluded from sampling (Childs et al., 2015). There are no default dead organic matter estimates across forest types provided by the IPCC (2006). Therefore, the change in dead organic matter carbon stocks from excavation/construction ($\Delta C_{excav\text{-}DOM}$) are either assumed to be encompassed by mangrove biomass estimates or excluded for other habitat types (e.g., tropical moist deciduous forest, tropical shrubland).

The extent of land cover types potentially disturbed by the Proposed Project was determined by geospatial analysis (see **Appendix K.4 – Habitats and Land Uses**) and grouped into cohesive habitat classifications or excluded from analysis (**Table 10-8**). Methodology for the geospatial analysis and descriptions of the habitats can be found within **Chapter 13**: **Terrestrial Ecology**. Habitat biomass estimates, calculated from the equations previously noted, and impact areas used in the analysis are provided in **Table 10-9**.

Table 10-8: Habitat Classifications

Habitat	Land Cover Type (GIS)	Assumptions / Justification
Mangroves	Seasonally flooded mangrove forest and woodland	Seasonally flooded mangrove biomass estimates specific to Grand Cayman (Childs et al., 2015) were applied to the mangrove habitat types in this assessment. No summary statistics (e.g., range of sample tree densities) within Childs et al. (2015) that could provide rationale for scaling estimates based on apparent density of mangrove habitats.
	Seasonally flooded mangrove shrubland	
	Seasonally flooded / saturated semi-deciduous forest	
	Seasonally flooded mangrove forest (low density)	
Tropical Moist Deciduous Forest (Older Secondary)	Dry forest and woodland	Grand Cayman contains very little primary (i.e., old-growth) forest (Childs et al., 2015). The area of remaining old-growth (Mastic) forest on the island (Childs et al., 2015) does not overlap with the proposed infrastructure developments. Additionally, IPCC estimates of secondary forest (>20 years) biomass for tropical moist deciduous forests (IPCC 2006; IPCC 2019) are only slightly less (appx. 10%) than biomass estimates specific to the old-growth (Mastic) forests generated by Childs et al. (2015). Therefore, we assume the IPCC default biomass estimate for Secondary (>20 years) tropical moist deciduous forests is representative of, and/or skews conservative compared to, the secondary deciduous forests across Grand Cayman.
	Palm Hammock	
	Seasonally flooded / saturated semi-deciduous forest	
Tropical Moist Deciduous Forest (Younger Secondary)	Man-modified with trees	Aerial imagery shows apparent anthropogenically degraded habitat in the early stages of forest regeneration. Conservatively classified as young (≤20 years) secondary tropical moist deciduous forest (IPCC, 2006; IPCC, 2019)
Tropical Moist Grassland	Man-modified without trees	Aerial imagery shows apparent converted / anthropogenically degraded habitat without trees. Conservatively classified as tropical grassland habitat (IPCC, 2006).
	Pasture	
Excluded	Agricultural	Land cover types excluded from analysis encompass built areas and infrastructure, human activities (e.g., agriculture, mining), and open-water systems that are assumed to be net sources of GHG emissions and/or contain biomass carbon stocks that are *de minimis* in their current state.
	Commercial	
	Disturbed land	
	Institutional	
	Mining	
	Residential	
	Roads	
	Man-Made Pond	
	Ponds, pools and mangrove lagoons	

Table 10-9: Habitat Biomass and Impact Area

Habitat*	Biomass MT CO_2e ha^{-1} (Tonne CO_2e ac^{-1})	Hectares** (Acres)
		Proposed Project
Mangroves	265.06 (118.24)	60.01 (148.29)
Tropical Moist Deciduous Forest (Older Secondary)	289.87 (129.31)	13.37 (33.03)
Tropical Moist Deciduous Forest (Younger Secondary)	123.3 (55.00)	2.67 (6.61)
Tropical Moist Grassland	27.78 (12.39)	20.32 (50.20)
Total		**96.37 (238.13)**

**Habitat classification is based on Table 10-8*
***Hectares (acres) of impact does not impact the "Excluded" habitat classification from Table 10-8*

Annual carbon sequestration loss from the Proposed Project anticipated impacts is evaluated within **Chapter 13: Terrestrial Ecology**.

10.2.3 Peat Data

The anticipated volume of peat that would need to be excavated was provided for the Proposed Project (**Table 10-10**). Because peat volumetric data lacked a geospatial component, this assessment assumed, with consideration to the dominance of peat-producing mangrove swamps on Grand Cayman (Childs et al., 2015), the peat to have (inland) mangrove habitat soil characteristics.

Table 10-10: Peat Volume Excavation

	Unit of Measure	Peat Excavation				
		2026 Quantity	2036 Quantity	2046 Quantity	2060 Quantity	Total
Proposed Project	Yd^3	219,448	119,597	68,922	33,612	441,579
	m^3	167,780	91,438	52,695	25,698	337,611

Country-specific data were sourced to estimate carbon content of peat excavated. Childs et al. (2015) estimated soil carbon stocks for inland mangrove habitats across the CMW using field sampling (i.e., soil cores). Soil carbon content varied little by depth (Childs et al., 2015). Therefore, the carbon content for excavated peat was assumed to be uniform and equal to the average of the entire soil profile for inland mangrove habitats (Childs et al., 2015). The methodology for determining the total quantity of peat removal for the Proposed Project is based on the trial pit data supplied by the NRA from 2008 and 2014. Additional information regarding peat quantities is provided within **Chapter 6: Proposed Project – Engineering Features**.

10.3 Project Impacts

This section describes the potential GHG emissions that are estimated to occur as a result of the Proposed Project. The Future No-Build condition is also included as a basis for comparison to demonstrate the impacts and benefits of the Proposed Project. The Proposed Project is described in **Chapter 6: Proposed Project - Engineering Features** and traffic evaluations **in Chapter 7: Transportation and Mobility**. **Chapter 15: Summary of Direct, Indirect, Secondary/Induced and Cumulative Effects** includes Secondary, Induced, and Cumulative impacts.

Due to the phasing of the construction timeline, the future years 2026, 2036, 2046 and three growth scenarios for 2074 (projected low, medium, and high population/development growth) were analysed for this discipline where appropriate.

The GHG analysis included the following emission sources within this chapter to establish anticipated Proposed Project emissions:

- Construction tailpipe emissions *(construction phase)*
- Commuter and delivery tailpipe emissions *(construction phase)*
- Habitat and peat removal *(construction phase)*
- Bulk materials (concrete, asphalt etc.) *(construction phase)*
- Traffic operations *(operational phase)*
- Annual carbon sequestration loss *(operational phase)*
- Solar array *(operational phase)*

A summary of the anticipated lifecycle GHG emissions can be found in **Section 10.3.3: Summary of Lifecycle Emissions**.

10.3.1 Construction Phase

10.3.1.1 Construction Tailpipe Emissions

For the anticipated road construction equipment, diesel emissions associated with running exhaust and crankcase exhaust were evaluated to establish the GHG emissions. The NONROAD component of the MOVES model directly outputs CO_2 and CH_4 emissions in grams per hour (g/hr). Nitrous oxide (N_2O) emissions are not directly outputted. Instead, EPA non-road vehicle emission factors from the EPA GHG Emission Factor Hub (EPA 2024a) were used to determine N_2O emissions. A ratio of the N_2O and CH_4 emission factors were applied as defined in Table 5 of the EPA GHG Emission Factor Hub. For example, diesel equipment in the Construction/Mining Equipment section of Table 6 of the EPA GHG Emission Factor Hub has a CH_4 factor of 1.01 grams/gallon (g/gal) and an N_2O factor of 0.94 g/gal (diesel off-highway trucks is 0.91 and 0.56 g/gal for CH_4 and N_2O, respectively). The CH_4 MOVES result for the equipment, besides trucks, was multiplied by the ratio, 0.94/1.01 g/gal, (0.56/0.91 g/gal for diesel off-highway trucks) to establish the N_2O equivalent results.

Table 10-11 illustrates the g/hr emission factors by each equipment type as example for opening year of 2026; emissions factors are from MOVES 2006 as outlined in **Table 10-1**. The data associated with the other analysis years are provided in **Appendix I.4 – Construction Emissions Analysis**.

Table 10-11: Construction Equipment Emission Factors (g/hr)

Activity	MOVES Output Name	CO_2	CH_4	N_2O
Road Construction	Pavers	40,352	1.15	1.07
	Rollers	30,458	0.82	0.76
	Excavators	54,647	1.70	1.58
	Graders	64,767	1.97	1.83
	Tractors/ Loaders/ Backhoes	12,989	0.53	0.49
	Crawler Tractor/ Dozers	82,948	1.99	1.85
	Dumpers/Tenders (Dump Trucks)	4,719	0.17	0.10
	Surfacing Equipment	36,806	0.69	0.64
Electrical Work	Tractors/ Loaders/ Backhoes	12,989	0.53	0.49
	Cranes	53,123	1.26	1.17
	Bore/ Drill Rigs	40,875	0.74	0.69
	Rough Terrain Forklifts	32,493	0.82	0.76
	Dumpers/ Tenders (Dump Trucks)	4,719	0.17	0.10
	Excavators	54,647	1.70	1.58

CO_2 and CH_4 emission factors were from MOVES 4.0.1 for a 2006 vehicular fleet as a representative worst-case scenario (Analysis Year 2026). Electrical work includes the installation of power poles, electrical lines, traffic lights, repair and maintenance. Potential solar array emission factors are not included

Potential GHG emissions were calculated from an assumed number of each equipment type, daily construction schedule, total workdays by activity, and an estimated percentage of equipment utilisation. The assumed values affect the GHG emissions. The construction GHG emissions estimated for the Proposed Project are a small portion of the overall potential GHG emissions. Note that dump truck emissions are addressed in part (50% or 4 hours per day [hr/day]) by off-road activities (construction and quarry travel) and the remainder under delivery truck on-road travel (appropriate assumed travel distance outlined in **Section 10.3.1.2**).

Table 10-12 outlines the projected emissions per construction phase for opening year of 2026 (See **Appendix I.4 – Construction Emissions Analysis** for the other years analysed). Lifetime (2026, 2036, 2046, 2060, and 2074) construction tailpipe emissions were estimated to emit 18,649 MT (20,557 short tons). The assumptions provided in **Table 10-12** will be updated during the detailed design and construction phases. Therefore, the potential GHG emission estimates are based on a conceptual EIA level and subject to change as design progresses.

Additionally, CO_2e is calculated in both short tons and MT[3] by applying standard EPA global warming potential values by pollutant. CO_2 has a multiplier of 1, the CH_4 multiplier is 25, and the N_2O multiplier is 298. (EPA 2024b).

[3] Note that a metric tonne corresponds to approximately 1.10231 short tons.

Table 10-12: Construction Tailpipe GHG Emissions (Opening Year 2026)

Activity	Equipment						Emissions Short Tons (MT) per Year							
	Type	Number	Daily Schedule (hr/day)	Total Workdays	% of Equipment Utilisation	Workdays of Equipment Utilisation	CO_2		CH_4		N_2O		CO_2e	
							Tons	MT	Tons	MT	Tons	MT	Tons	MT
Road Construction	Pavers	4	8	697	33	230	327.4	297.0	9.4E-03	8.5E-03	8.7E-03	7.9E-03	330.2	299.6
	Rollers	4	8	697	50	349	375.0	340.2	1.0E-02	9.1E-03	9.4E-03	8.5E-03	378.0	342.9
	Excavators	4	8	697	75	523	1008.1	914.6	3.1E-02	2.8E-02	2.9E-02	2.6E-02	1017.6	923.2
	Graders	4	8	697	50	349	797.3	723.3	2.4E-02	2.2E-02	2.3E-02	2.0E-02	804.7	730.0
	Loaders	3	8	697	75	523	179.7	163.0	7.3E-03	6.6E-03	6.8E-03	6.2E-03	181.9	165.0
	Dozers	4	8	697	75	523	1530.2	1388.2	3.7E-02	3.3E-02	3.4E-02	3.1E-02	1541.4	1398.3
	Dumpers (Dump Trucks)	20	4	697	100	697	290.0	263.1	1.0E-02	9.3E-03	6.3E-03	5.7E-03	292.2	265.1
	Surfacing Equipment	2	8	697	33	230	149.3	135.4	2.8E-03	2.5E-03	2.6E-03	2.3E-03	150.1	136.2
Electrical Work	Loaders	2	8	465	75	349	80.0	72.5	3.2E-03	2.9E-03	3.0E-03	2.7E-03	80.9	73.4
	Cranes	1	8	465	25	116	54.3	49.3	1.3E-03	1.2E-03	1.2E-03	1.1E-03	54.7	49.7
	Drill Rigs	1	8	465	33	153	55.1	50.0	1.0E-03	9.1E-04	9.3E-04	8.5E-04	55.5	50.3
	Forklifts	1	8	465	75	349	100.0	90.7	2.5E-03	2.3E-03	2.4E-03	2.1E-03	100.8	91.4
	Dumpers (Dump Trucks)	1	4	465	100	465	9.7	8.8	3.4E-04	3.1E-04	2.1E-04	1.9E-04	9.7	8.8
	Excavators	1	8	465	75	349	168.2	152.6	5.2E-03	4.7E-03	4.9E-03	4.4E-03	169.8	154.0
Total CO_2e Short Tons (MT)														**5,167.5 (4,687.9)**

Results are rounded where appropriate.

10.3.1.2 Commuter and Delivery Tailpipe Emissions

In addition to the construction equipment, there would be GHG tailpipe emissions from workers commuting and material delivery trucks. Based on the size of Grand Cayman it was determined that the likely average distance a worker may travel one-way is about 6 mi (9.6 km) with a daily round trip of about 12 mi (19.3 km) per vehicle. For the purposes of this evaluation, it was estimated that the Proposed Project would comprise of a 200-worker crew. It was also assumed that each worker was allocated one personal vehicle to travel to and from the work site.

Material delivery operations were estimated to utilise a dedicated fleet of 10-20 delivery vehicles (trucks), with daily delivery truck trips ranging from approximately 46 to 333 depending on anticipated construction phase year at this conceptual design level; these assumptions are subject to change based on the detailed design phase outside of this EIA. As most of the materials quantified for construction are anticipated to be moved within the vicinity of the Proposed Project or obtained from adjacent quarries, the estimated distance of delivery truck trips was 12 mi (19.3 km) round trip. For emission calculations, the number of workdays for the Proposed Project remained consistent as shown in **Table 10-6**.

The commuter vehicle fleet assumed 80% gasoline passenger cars, 15% gasoline passenger trucks and 5% diesel-fuelled trucks. The delivery trucks were assumed to be heavy duty diesel short haul combination trucks. **Table 10-12** illustrates the general information and calculated emission factor in grams per vehicle mile (g/veh-mi) for commuting and delivery for each analysis phase/year. The round-trip travel distance was assumed to be 12.0 mi (19.3 km) for both commuting and delivery vehicles. Each delivery truck was estimated to contain 10 yd^3 of material. The MOVES model years and corresponding analysis years are consistent with **Table 10-1**.

Table 10-13 provides the projected GHG emissions associated with the Proposed Project. Emissions provided in **Table 10-13** are based on the g/veh-mi factors outlined in **Table 10-12**. Total construction vehicle tailpipe emissions are summarized in **Table 10-14**.

Table 10-13: Commuting and Delivery Vehicles

Activity	Year	Manhours/ phase	Months/ Phase	Crew Size	Hrs/crew member/mo.	Days/crew member/ Mo.	Vehicles miles travelled	CO2e (gr/veh-mi)
Commuting Vehicles								
Road Construction	2026	1,393,299	24	200	290	29	1,671,959	471.82
	2036	1,393,299	24		290	29	1,671,959	362.82
	2046	1,114,639	24		232	23	1,337,567	311.74
	2060	1,114,639	24		232	23	1,337,567	264.58
	2074	557,320	12		232	23	668,783	224.55
Activity	**Year**	**Workdays**	**Trips per Phase**	**Trips/ day**	**Truck Miles**	**CO2e (gr/veh-mi)**		
Delivery Vehicles								
Road Construction	2026	697	232,196	333	2,786,352	1,967.53		
	2036	697	152,148	218	1,825,776	1,735.60		
	2046	557	71,931	129	863,172	1,510.07		
	2060	557	69,092	124	829,104	1,495.63		
	2074	279	12,844	46	154,128	1,481.33		

Table 10-14: Vehicle Tailpipe GHG Emissions

Activity	2026	2036	2046	2060	2074	Lifetime
	Short Tons CO2e (MT)					
Commuting Vehicles	869.57 (788.86)	668.68 (606.62)	459.63 (416.97)	390.10 (353.89)	165.54 (150.18)	2,553.52 (2,316.52)
Delivery Vehicles	6,043.13 (6,482.24)	3,493.03 (3,168.82)	1,436.81 (1,303.45)	1,366.90 (1,240.03)	251.67 (228.31)	12,591.54 (11,422.86)
Total	**6,912.69 (6,271.10)**	**4,161.71 (3,775.44)**	**1,896.44 (1,720.42)**	**1,757.00 (1,593.91)**	**417.21 (378.49)**	**15,145.06 (13,739.38)**

10.3.1.3 Habitat and Peat Emissions

Emissions from the removal/excavation of biomass and peat deposits were estimated for the Proposed Project (**Tables 10-15** and **10-16**). The magnitude of emissions from biomass removal varies by habitat. Impacts to mangroves are the most predominant for the Proposed Project, constituting 84% of total GHG emissions from biomass removal. When impacts to both carbon pools (i.e., biomass and peat) are combined, the Proposed Project is estimated to emit 73,588.97 MT CO_2e (81,117.85-tonne CO_2e) from habitat clearing and peat excavation. Note that peat removal is expected to cease by 2060.

Table 10-15: GHG Emissions from Biomass Removal Across Habitat Types for Proposed Project

	Mangroves	Tropical Moist Deciduous Forest (Older Secondary)	Tropical Moist Deciduous Forest (Younger Secondary)	Tropical Moist Grassland	Total
	MT CO_2e (Tonne CO_2e)	MT CO_2e (Tonne CO_2e)	MT CO_2e (Tonne CO_2e)	MT CO_2e (Tonne CO_2e)	MT CO_2e (Tonne CO_2e)
Proposed Project	15,906.70 (17,534.11)	775.40 (854.73)	1,648.11 (1,816.73)	564.36 (622.10)	18,894.56 (20,827.67)

Table 10-16: GHG Emissions from Habitat and Peat Impacts for Proposed Project

	Habitat (Biomass) Removal	Peat Excavation	Total
	MT CO_2e (Tonne CO_2e)	MT CO_2e (Tonne CO_2e)	MT CO_2e (Tonne CO_2e)
Proposed Project	18,894.56 (20,827.67)	54,694.40 (60,290.19)	73,588.97 (81,117.85)

Peat impacts account for most of the emissions for the Proposed Project. This finding is consistent with the consensus on carbon cycling in coastal wetlands, where most of the ecosystem carbon is found in the soils (Donato et al., 2011).

Assumptions and Exclusions Summary

- The carbon stored in biomass and peat that is removed/excavated during construction is assumed to be lost and subsequently and immediately emitted as CO_2 to the atmosphere. Actual emissions from these extracted materials may vary quantitively and temporally, depending on their use (e.g., wood products), storage conditions and/or method of disposal (e.g., burning, *in-situ* decomposition).
- Mangrove biomass estimates encompass dead wood carbon stock (Childs et al., 2015).
- Mangrove litter carbon stocks are assumed *de minimis* (Childs et al., 2015).
- Impacts to dead organic matter (DOM) carbon stocks were excluded from analysis for non-mangrove habitat types as regional and/or default DOM estimates (IPCC, 2006; IPCC, 2019) were unavailable.
- Land cover types excluded from the analysis contain carbon stocks that are either *de minimis* or are net sources of GHG emissions (i.e., conservatively excluded).
- It is assumed the Proposed Project would not lead to leakage impacts outside of the LOD from the displacement of land use activities (e.g., agriculture, mining) and within wetland (e.g., mangrove) habitats due to hydrological changes that may produce indirect GHG emissions.

- The average soil organic carbon content and depth of inland mangrove habitats (Childs et al., 2015) is assumed to be representative of the estimated peat excavated across LODs. Actual carbon content of extracted peat is likely variable across environmental gradients and by depth.
- The accuracy of the assessment is based on data that were provided and/or sourced in the form of habitat mapping, peat extraction data, and primary literature.

10.3.1.4 Bulk Material Emissions

The Carbon Tool breaks down densities and emission factors by general material. This analysis included a review of the densities and emission factors and then correlated each quantity type to an appropriate density/emission factor. **Table 10-17** describes data applied to calculate GHG emissions.

Table 10-17: Emission Factor/Density by Material Breakdown

Quantity Name	Carbon Tool Density Category	Density tonnes/m^3	Emission Factors	Units	Carbon Tool Factor Category
Asphalt	Asphalt	2.3	0.055	tCO_2e/t	Asphalt
Rock	Quarried Aggregate	2	0.007		General Mixture
Concrete	Concrete	2.4	0.103		General Concrete
Excavation	Soil	1.7	0.007		General Mixture
Kerb	Concrete	2.4	0.132		Pre-cast Concrete
Markings	Plastic	1.4	5.7		Thermoplastic
Light poles[1]	Steel	0.132	2.76		Steel 8m
Walls/Barrier	Concrete	2.4	0.122		General Concrete
Guard Rails	Structural Steel	7.8	2.102		Structural Steel
Concrete Pipe[2]	Precast Pipe	883 lb/lf	0.1461		Concrete Precast Pipe
Pipe End[2]	Reinforced Concrete	6500 lb/item	0.249		Reinforced Concrete
Conduit[2]	PVC	2.938 lb/lf	3.230		PVC
Non-Woven Geotextile	Geotextile	250 g/m^2	2.665		Non-Woven Geotextile
Traffic Signal, Bus Shelter, Attenuator	Aluminium	2.7	13.200		Aluminium, Cast
Stainless Steel	Steel	8	4.407		Stainless Steel, 20% Ni
Bus Shelter	Safety Glass	2.5	2.080		Safety Glass
Attenuator	Aluminium	2.7	13.000		Aluminium, Sheet
Attenuator	HDPE	0.97	2.520		HDPE

1 Light pole conversion is 0.132 tonnes per pole
2. Values in Density column represent a material weight rather than density.

To determine a volume from the known linear feet total, pavement markings width and thickness was assumed to be 6 in (15.24 cm) and 0.118 in (3 mm), respectively (FHWA 2015, SRRB 2015). Tack coat calculations incorporated a thickness of 0.0098 in (0.25 mm) (Blacklidge 2020). In addition, the concrete barrier calculations applied a triangle shape, and the area is determined by 1/2 base multiplied by the height. The base is 2 ft (0.6096 m) and a height of 3 ft (0.9144 m). The following **Tables 10-18** and **10-19** provide the projected GHG emissions associated with the Proposed Project in MT and short tons, respectively. Note that the Will T Connector is encompassed within the Proposed Project. Therefore, its emissions are added to Proposed Project. The Future No-Build includes bulk material related emissions and are incorporated within **Tables 10-20** and **10-21** for inclusion with the CBA. Overall, the Proposed Project is estimated to emit 107,974.20 short tons (97,952.66 MT). Future No-Build emissions are expected to be 11,062.55 short tons (10,035.78 MT). Similar to the peat removal, new construction is expected to cease by 2060, but rehabilitation and resurfacing associated with the EIA is expected to continue through 2074.

Table 10-18: Proposed Project Bulk Material Emissions by Material Type (Metric Tonnes)

Material Type	2026	2036	2046	2060	2074	Lifetime
		MT CO2e				
Compacted Asphalt, 2" Depth	0.00	1,419.78	2,257.49	2,719.41	3,181.90	9,578.57
Compacted Asphalt, 3.5" Depth	2,484.61	1,465.99	517.93	3,741.86	26.95	8,237.34
Compacted Asphalt, 6" Depth	0.00	407.32	516.51	407.32	516.51	1,847.67
Crusher Run, 6" Depth	471.39	278.13	98.26	709.92	5.11	1,562.82
Cayman Rock, 6" Depth	485.35	361.68	197.27	723.79	69.25	1,837.34
Milling, 2" Depth	0.00	1,419.78	2,393.26	2,891.58	3,181.90	9,886.52
Asphalt Tack Coat	0.00	13.97	23.56	28.46	31.32	97.31
Concrete Traffic Separator	33.67	33.57	0.00	33.57	0.00	100.82
Concrete Pavement, 6" Depth	244.94	649.52	738.86	894.46	738.86	3,266.64
Concrete Curb, 6" Height	34.62	83.13	11.79	54.05	11.79	195.37
Concrete Curb & Gutter, 6" Height	72.20	0.00	0.39	147.25	0.39	220.23
Concrete Median Barrier	1,394.42	315.79	2,788.85	1,394.42	1,394.42	7,287.92
Concrete Median Barrier Attenuator	322.82	699.45	807.06	1,022.27	1,022.27	3,873.88
Guard Rail Median Barrier	0.00	820.13	0.00	0.00	0.00	820.13
Guard Rail Median Barrier Attenuator	0.00	188.31	0.00	0.00	0.00	188.31
Guard Rail	187.79	187.79	187.79	187.79	187.79	938.94
Guard Rail Anchor Terminal	13.71	13.71	16.45	20.56	20.56	84.99
Guard Rail Attenuator	807.06	807.06	968.47	1,210.59	1,210.59	5,003.76
Remove & Reset 48" Concrete Pipe End Section	0.00	158.57	79.29	0.00	0.00	237.86
48" Concrete Pipe End Section	158.57	0.00	0.00	55.79	0.00	214.37
48" Reinforced Concrete Pipe	704.68	404.01	190.71	109.02	0.00	1,408.43
Pavement Markings - Longitudinal	240.59	384.58	382.47	615.07	615.07	2,237.78
Pavement Markings - Legend Arrows	0.51	1.58	1.58	1.58	1.58	6.82
Conduit (Lighting)	187.47	7.75	71.02	194.57	0.00	460.82
Light Poles	74.32	17.49	23.68	42.63	0.00	158.11
Noise Wall	0.00	0.00	0.00	68.60	0.00	68.60
Traffic Signal & Pre-emption System	0.00	33.34	0.00	33.34	0.00	66.68
Traffic Signal at U-Turns LOCATION (2 Mast Arms)	0.00	0.00	0.00	4.61	0.00	4.61
Traffic Signal (3 Mast Arms)	0.00	6.45	0.00	6.45	0.00	12.90
Traffic Signal (4 Mast Arms)	0.00	0.00	0.00	8.29	0.00	8.29
Bus Stop Shelter	0.00	395.78	79.16	474.94	0.00	949.87
Geotextile fabric, Non-woven	116.72	93.02	41.31	31.28	0.00	282.34
Hammer Rock Slope Protection	996.79	794.34	352.79	267.16	0.00	2,411.07
Undercut Excavation	227.56	158.35	23.10	60.28	0.00	469.29
Aggregate Borrow Material (18" Rock)	2,616.63	1,466.43	764.90	430.70	0.00	5,278.66
Embankment Material (Shot Rock)	12,762.03	8,450.27	3,422.21	2,241.18	0.00	26,875.69
General Excavation	109.37	36.75	0.00	1,517.05	108.77	1,771.93
Total	**24,747.83**	**21,573.81**	**16,956.15**	**22,349.85**	**12,325.02**	**97,952.66**

Table 10-19: Proposed Project Bulk Material Emissions by Material Type (Short Tons)

Material Type	2026	2036	2046	2060	2074	Lifetime
	Short Tons CO2e					
Compacted Asphalt, 2" Depth	0.00	1565.04	2488.45	2997.63	3507.44	10,558.56
Compacted Asphalt, 3.5" Depth	2738.81	1615.98	570.92	4124.69	29.71	9,080.10
Compacted Asphalt, 6" Depth	0.00	448.99	569.35	448.99	569.36	2,036.70
Crusher Run, 6" Depth	519.62	306.59	108.31	782.55	5.64	1,722.71
Cayman Rock, 6" Depth	535.01	398.68	217.45	797.84	76.33	2,025.32
Milling, 2" Depth	0.00	1565.04	2638.11	3187.42	3507.44	10,898.01
Asphalt Tack Coat	0.00	15.40	25.97	31.37	34.52	107.26
Concrete Traffic Separator	37.11	37.00	0.00	37.00	0.00	111.13
Concrete Pavement, 6" Depth	270.00	715.97	814.45	985.97	814.45	3,600.85
Concrete Curb, 6" Height	38.16	91.64	13.00	59.58	12.99	215.36
Concrete Curb & Gutter, 6" Height	79.59	0.00	0.43	162.32	0.43	242.76
Concrete Median Barrier	1537.08	348.10	3074.18	1537.08	1537.09	8,033.54
Concrete Median Barrier Attenuator	355.85	771.01	889.63	1126.86	1126.86	4,270.22
Guard Rail Median Barrier	0.00	904.04	0.00	0.00	0.00	904.04
Guard Rail Median Barrier Attenuator	0.00	207.58	0.00	0.00	0.00	207.58
Guard Rail	207.00	207.00	207.00	207.00	207.00	1,035.00
Guard Rail Anchor Terminal	15.11	15.11	18.13	22.66	22.67	93.69
Guard Rail Attenuator	889.63	889.63	1067.55	1334.45	1334.44	5,515.70
Remove & Reset 48" Concrete Pipe End Section	0.00	174.79	87.40	0.00	0.00	262.20
48" Concrete Pipe End Section	174.79	0.00	0.00	61.50	0.00	236.30
48" Reinforced Concrete Pipe	776.78	445.34	210.22	120.17	0.00	1,552.53
Pavement Markings - Longitudinal	265.20	423.93	421.60	678.00	678.00	2,466.73
Pavement Markings - Legend Arrows	0.56	1.74	1.74	1.74	1.74	7.52
Conduit (Lighting)	206.65	8.54	78.29	214.48	0.00	507.96
Light Poles	81.92	19.28	26.10	46.99	0.00	174.29
Noise Wall	0.00	0.00	0.00	75.62	0.00	75.62
Traffic Signal & Pre-emption System	0.00	36.75	0.00	36.75	0.00	73.50
Traffic Signal at U-Turns Locations (2 Mast Arms)	0.00	0.00	0.00	5.08	0.00	5.08
Traffic Signal (3 Mast Arms)	0.00	7.11	0.00	7.11	0.00	14.22
Traffic Signal (4 Mast Arms)	0.00	0.00	0.00	9.14	0.00	9.14
Bus Stop Shelter	0.00	436.27	87.26	523.53	0.00	1,047.05
Geotextile fabric, Non-woven	128.66	102.54	45.54	34.48	0.00	311.22
Hammer Rock Slope Protection	1098.77	875.61	388.88	294.49	0.00	2,657.74
Undercut Excavation	250.84	174.55	25.46	66.45	0.00	517.30
Aggregate Borrow Material (18" Rock)	2884.34	1616.46	843.16	474.76	0.00	5,818.72
Embankment Material (Shot Rock)	14067.71	9314.82	3772.34	2470.48	0.00	29,625.34
General Excavation	120.56	40.51	0.00	1672.26	119.90	1,953.22
Total	**27,279.78**	**23,781.03**	**18,690.93**	**24,560.84**	**13,586.00**	**107,974.20**

Table 10-20: Future No-Build Bulk Material Emissions by Material Type (Metric Tonnes)

Material Type	2026	2036	2046	2060	Lifetime
	MT CO2e				
Compacted Asphalt, 2" Depth	967.25	967.25	0.00	967.25	2,901.76
Compacted Asphalt, 3.5" Depth	169.27	169.27	1,692.69	169.27	2,200.50
Crusher Run, 6" Depth	32.11	32.11	321.14	32.11	417.49
Cayman Rock, 6" Depth	32.11	32.11	321.14	32.11	417.49
Milling, 2" Depth	967.25	967.25	0.00	967.25	2,901.76
Asphalt Tack Coat	10.00	10.00	4.76	10.00	34.75
Pavement Markings, White	53.93	53.93	53.93	53.93	215.74
General Excavation	72.79	72.79	727.93	72.79	946.30
Total	**2,304.73**	**2,304.73**	**3,121.60**	**2,304.73**	**10,035.78**

Table 10-21: Future No-Build Bulk Material Emissions by Material Type (Short Tons)

Material Type	2026	2036	2046	2060	Lifetime
	Short Tons CO2e				
Compacted Asphalt, 2" Depth	1,066.21	1,066.21	0.00	1,066.21	3,198.64
Compacted Asphalt, 3.5" Depth	186.59	186.59	1,865.87	186.59	2,425.63
Crusher Run, 6" Depth	35.40	35.40	354.00	35.40	460.20
Cayman Rock, 6" Depth	35.40	35.40	354.00	35.40	460.20
Milling, 2" Depth	1,066.21	1,066.21	0.00	1,066.21	3,198.64
Asphalt Tack Coat	11.02	11.02	5.25	11.02	38.30
Pavement Markings, White	59.45	59.45	59.45	59.45	237.81
General Excavation	80.24	80.24	802.40	80.24	1,043.12
Total	**2,540.52**	**2,540.52**	**3,440.97**	**2,540.52**	**11,062.55**

10.3.2 Operation Phase

The project-level MOVES model outputs emissions on an hourly basis to best represent daily and annual potential emissions. Model output was calculated for the 2021 Baseline during the peak morning AM and peak afternoon/evening PM hours for both the road segments and intersections.

Consistent with the construction emissions described in **Sections 10.3.1.1** and **10.3.1.2**, traffic GHG emissions of CO_2, CH_4, and N_2O were determined along with CO_2e. CO_2e emissions were calculated by MOVES but are based on U.S. EPA global warming potential multipliers. CO_2e is calculated by applying standard EPA global warming potential values by pollutant. CO_2 has a multiplier of 1, the CH_4 multiplier is 25, and the N_2O multiplier is 298. (EPA 2024b).

Traffic on the various road segments included running exhaust and crankcase exhaust emissions. Intersection segments calculated the emissions from the same vehicle processes. Extended idling was not included as the MOVES output corresponds specifically to overnight idling of long-haul trucks and terminals, which would not apply to the Proposed Project. Normal operation for the identified vehicle types such as stopping at traffic signals and truck loading and unloading are accounted for within the running exhaust calculations (EPA 2023).

The 2021 Baseline road segment emissions are estimated to be 7.37 MT (8.13 short tons) CO_2e for the morning AM peak hour and 10.44 MT (11.50 short tons) for the afternoon PM peak hour. The four intersections with the projected highest traffic volumes generate an average of between 0.33 (0.36) and 0.44 (0.49) MT (short tons) per hour for the peak AM and PM hours, respectively.

To establish daily emission totals, non-peak hour emissions were calculated using percentages of volumes relative to the peak hours (AM peak hour from 6:00-7:00 AM; PM peak hour from 5:00-6:00 PM) (see **Chapter 7: Transportation and Mobility** for more detail as to how the peak hours were determined). **Table 10-22** shows the emission percentage per hour throughout the day. **Table 10-22** represents two-way traffic volumes, with the majority of morning commuters heading westbound toward George Town. Based on 2023 count data, most westbound travel within the EIA study area occurs during 6-7 AM, which is why this hour was chosen as the "peak" hour to be modelled. However, eastbound traffic in the off-peak direction increases from 7-9 AM, though it remains lower than westbound traffic volumes. Because the tabular data shows two-way traffic, the rising percentage of eastbound vehicles during 7-9 AM results in higher two-way traffic volumes than the selected 6-7 AM peak hour.

Table 10-22: Two-Way Daily Hourly Traffic Volumes and Distribution

Hour[1]	Shamrock Rd: West of Little Red Road	Shamrock Rd: East of Midnight Road	Shamrock Rd: West of Arrow Road	Bodden Town Rd, east of Anton Bodden Rd	Bodden Town Rd, west of Frank Sound Rd	Condor Rd: North of Shamrock Road	Total of All Road Segments	% of Daily Total
AM Hours								
12:00 AM	138	124	101	102	53	31	**548**	0.64%
01:00	69	66	90	57	35	11	**326**	0.38%
02:00	51	46	58	36	18	12	**220**	0.26%
03:00	43	41	58	27	16	8	**192**	0.22%
04:00	109	107	103	53	57	24	**453**	0.53%
05:00	878	836	793	398	425	200	**3,529**	4.10%
06:00	1,385	1,047	945	564	370	269	**4,580**	5.32%
07:00	1,420	1,185	881	700	596	317	**5,099**	5.93%
08:00	1,322	1,223	1,069	776	660	343	**5,393**	6.27%
09:00	1,166	1,076	924	650	495	213	**4,524**	5.26%
10:00	1,089	1,002	862	641	459	194	**4,247**	4.94%
11:00	1,086	1,006	897	643	446	168	**4,246**	4.94%
PM Hours								
12:00 PM	1,027	939	824	653	457	193	**4,092**	4.76%
01:00	1,100	1,016	957	674	497	180	**4,423**	5.14%
02:00	1,148	1,077	978	710	546	247	**4,706**	5.47%
03:00	1,365	1,253	1,115	803	549	328	**5,412**	6.29%
04:00	1,531	1,399	1,162	874	557	302	**5,823**	6.77%
05:00	1,597	1,471	1,228	899	586	310	**6,091**	7.08%
06:00	1,578	1,416	1,159	832	563	329	**5,877**	6.83%
07:00	1,492	1,366	1,073	757	501	333	**5,522**	6.42%
08:00	1,077	997	900	622	360	214	**4,167**	4.84%
09:00	841	772	704	472	301	197	**3,285**	3.82%
10:00	540	490	481	319	204	112	**2,144**	2.49%
11:00	272	259	253	170	120	57	**1,130**	1.31%
Day Total	22,321	20,211	17,611	12,428	8,867	4,590	**86,027**	100.0%

1. The highlighted areas refer to the peak AM/PM hours.

Hourly emissions factors were then applied for the identified road segments and intersections. As a worst-case approach, the annual emissions assumed daily totals for 365 days. To account for the identified intersections, a static multiplier was applied to the modelled hourly output based on the Future No-Build. The Future No-Build and the 2021 Baseline used a multiplier of 3.25 (13 intersections); while the Proposed Project used variable multipliers based on the segment type (see **Section 10.1.3.2: Intersection Traffic Data** and **Table 10-4** for segment information). The analysis applied a roundabout multiplier of 2.0 and 3.5 for U-Turns to represent the full extent of the Proposed Project. Intersection multipliers were 3.33 for opening year 2026 and 3.4 for the other future years analysed. This is another part of the worst-case approach since there are four modelled segments that are projected to have the highest traffic volumes, while the remaining are not likely to experience nearly the same volumes. However, the multiplier approach assumes that all of these groups of segments are equivalent.

The following subsections outline the modelled GHG traffic emissions for the 2021 Baseline and future years (2026, 2036, 2046 and 2074 low, medium, high). Note that four criteria pollutants (carbon monoxide, nitrogen oxides, volatile organic compounds and particulate matter of 2.5 microns or less) were also modelled for the 2021 Baseline and future years (2026, 2036, 2046 and 2074 low, medium, high) for inclusion within the CBA. These results are available in **Chapter 16: Cost Benefit Analysis** and **Appendix I.3 – Critical Pollutants Analysis Results**.

10.3.2.1 2021 Baseline Emissions

The 2021 Baseline emissions were determined for 2021 using MOVES 4.0.1 based on the six primary road segments referenced in **Section 10.1.3.1: Road Segment Traffic Data** and the intersection locations referenced in **Section 10.1.3.2: Intersection Traffic Data.** As a worst-case approach, the annual GHG emissions were based on 365 days. The modelled AM hour (6:00-7:00 AM) produced 8.13 tonne/hr (7.37 MT/hr), and the PM hour (5:00-6:00 PM) produced 11.50 tonne/hr (10.44 MT/hr). **Table 10-23** shows the projected annual totals as 65,832.09 tonne/yr (59,721.94 MT/yr.).

Table 10-23: Baseline (2021) Annual Emissions (CO_2e)

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	0.97 (0.88)	12:00 PM	7.73 (7.01)	12:00 AM	0.14 (0.13)	12:00 PM	1.06 (0.96)
01:00	0.58 (0.52)	01:00	8.35 (7.58)	01:00	0.08 (0.08)	01:00	1.15 (1.04)
02:00	0.39 (0.35)	02:00	8.89 (8.06)	02:00	0.06 (0.05)	02:00	1.22 (1.11)
03:00	0.34 (0.31)	03:00	10.22 (9.27)	03:00	0.05 (0.04)	03:00	1.41 (1.28)
04:00	0.80 (0.73)	04:00	11.00 (9.98)	04:00	0.12 (0.11)	04:00	1.51 (1.37)
05:00	6.26 (5.68)	05:00	11.50 (10.44)	05:00	0.91 (0.82)	05:00	1.58 (1.44)
06:00	8.13 (7.37)	06:00	11.10 (10.07)	06:00	1.18 (1.07)	06:00	1.53 (1.38)
07:00	9.05 (8.21)	07:00	10.43 (9.46)	07:00	1.31 (1.19)	07:00	1.43 (1.30)
08:00	9.08 (8.24)	08:00	7.87 (7.14)	08:00	1.32 (1.19)	08:00	1.08 (0.98)
09:00	8.03 (7.28)	09:00	6.20 (5.63)	09:00	1.16 (1.06)	09:00	0.85 (0.77)
10:00	7.54 (6.84)	10:00	4.05 (3.67)	10:00	1.09 (0.99)	10:00	0.56 (0.51)
11:00	7.53 (6.84)	11:00	2.13 (1.93)	11:00	1.09 (0.99)	11:00	0.29 (0.27)
Total	**58.71 (53.26)**		**99.47 (90.24)**		**8.50 (7.71)**		**13.68 (12.41)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	21,428.22 (19,439.38)		**36,306.51 (32,936.75)**		**3,104.05 (2,815.95)**		**4,993.31 (4,529.86)**
Annual Combined Total	**65,832.09 (59,721.94)**						

Results are rounded where appropriate.

10.3.2.2 2026 Emissions

The 2026 opening year emissions were evaluated for the Proposed Project and Future No-Build using MOVES 4.0.1. The opening year and the other Proposed Project years evaluated 10 road segments along the EWA. **Appendix I.1 - Traffic Data for GHG Analysis** provides information on the road segments by analysis year. Emissions for opening year 2026 were calculated using the same methodology as the 2021 Baseline emissions, except with the vehicle age and corresponding fuel distribution equivalent to 2006 U.S. values. The vehicle and fuel distribution amongst this analysis year is consistent between the Future No-Build and Proposed Project.

Future No-Build Conditions

The 2026 Future No-Build GHG traffic emissions were determined via MOVES as a basis for comparison to the Proposed Project. The 2026 Future No-Build had 11,442 maximum morning and evening hourly vehicles (5,037 AM and 6,405 PM). Additionally, the modelled average speed by segment was approximately 33.2 mph (53.4 km/h). **Table 10-24** illustrates the expected annual GHG emissions of 75,191 short tons (68,212 MT) for the 2026 Future No-Build conditions. Refer to **Tables A-4** and **A-5** in **Appendix I.1 - Traffic Data for GHG Analysis** for specific details of 2026 Future No-Build road segment data.

Proposed Project

The 2026 Proposed Project incorporated 12,633 aggregate hourly vehicles at approximately 37.1 mph (59.7 km/h). The combined distances travelled for the Proposed Project is 23.6 mi (38.0 km). Refer to **Tables A-6** and **A-7** in **Appendix I.1 - Traffic Data for GHG Analysis** for specific details of the 2026 Proposed Project road segment data. Fuel distribution/vehicle type changes affected the projected emissions. For example, the percentage of transit buses increased, and diesel usage of single unit haul trucks increased from the 2021 Baseline, contributing to a projected increase of GHG emissions as shown in **Table 10-25**.

The 2026 Proposed Project is predicted to emit 86,350 short tons (78,335 MT) of GHGs annually. The emissions are directly correlated to the overall distance travelled, the total volume of vehicles, vehicle/fuel type and distribution, and travelling speed of the vehicles. The Proposed Project will accommodate more east-west travel through the study area during 2026 (100,853 vehicles/day) and the future analysis years. While the vehicle emission factors are improved to 2006 equivalence, the change is not enough to see a net reduction in GHG emissions from the 2021 Baseline. However, roadway capacity is added which induces demand and makes east-west travel more accessible (**Chapter 7: Transportation and Mobility**).

Table 10-24: 2026 Future No-Build Annual Emissions (CO_2e)

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	1.20 (1.09)	12:00 PM	8.82 (8.00)	12:00 AM	0.15 (0.13)	12:00 PM	0.87 (0.79)
01:00	0.71 (0.65)	01:00	9.54 (8.65)	01:00	0.09 (0.08)	01:00	0.94 (0.85)
02:00	0.48 (0.44)	02:00	10.15 (9.20)	02:00	0.06 (0.05)	02:00	1.00 (0.91)
03:00	0.42 (0.38)	03:00	11.67 (10.59)	03:00	0.05 (0.05)	03:00	1.15 (1.04)
04:00	0.99 (0.9)	04:00	12.55 (11.39)	04:00	0.12 (0.11)	04:00	1.24 (1.12)
05:00	7.72 (7.01)	05:00	13.13 (11.91)	05:00	0.94 (0.86)	05:00	1.29 (1.17)
06:00	10.02 (9.09)	06:00	12.67 (11.50)	06:00	1.22 (1.11)	06:00	1.25 (1.13)
07:00	11.16 (10.12)	07:00	11.9 (10.80)	07:00	1.36 (1.24)	07:00	1.17 (1.06)
08:00	11.20 (10.16)	08:00	8.99 (8.15)	08:00	1.37 (1.24)	08:00	0.89 (0.80)
09:00	9.90 (8.98)	09:00	7.08 (6.43)	09:00	1.21 (1.10)	09:00	0.70 (0.63)
10:00	9.30 (8.43)	10:00	4.62 (4.19)	10:00	1.13 (1.03)	10:00	0.46 (0.41)
11:00	9.29 (8.43)	11:00	2.43 (2.21)	11:00	1.13 (1.03)	11:00	0.24 (0.22)
Total	**72.41 (65.69)**		**113.56 (103.02)**		**8.84 (8.02)**		**11.19 (10.15)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	26,430.29 (23,977.18)		**41,449.83 (37,602.70)**		**3,225.77 (2,926.37)**		**4,084.92 (3,705.78)**
Annual Combined Total	**75,190.80 (68,212.03)**						

Results are rounded where appropriate.

Table 10-25: 2026 Proposed Project Annual Emissions (CO_2e)

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	1.43 (1.3)	12:00 PM	9.54 (8.65)	12:00 AM	0.18 (0.17)	12:00 PM	1.27 (1.15)
01:00	0.85 (0.77)	01:00	10.31 (9.35)	01:00	0.11 (0.10)	01:00	1.37 (1.25)
02:00	0.57 (0.52)	02:00	10.97 (9.95)	02:00	0.07 (0.07)	02:00	1.46 (1.33)
03:00	0.50 (0.45)	03:00	12.61 (11.44)	03:00	0.06 (0.06)	03:00	1.68 (1.52)
04:00	1.18 (1.07)	04:00	13.57 (12.31)	04:00	0.15 (0.14)	04:00	1.81 (1.64)
05:00	9.21 (8.35)	05:00	14.20 (12.88)	05:00	1.19 (1.08)	05:00	1.89 (1.72)
06:00	11.95 (10.84)	06:00	13.70 (12.43)	06:00	1.54 (1.40)	06:00	1.83 (1.66)
07:00	13.3 (12.07)	07:00	12.87 (11.68)	07:00	1.72 (1.56)	07:00	1.71 (1.56)
08:00	13.35 (12.11)	08:00	9.71 (8.81)	08:00	1.72 (1.56)	08:00	1.29 (1.17)
09:00	11.8 (10.71)	09:00	7.66 (6.95)	09:00	1.52 (1.38)	09:00	1.02 (0.93)
10:00	11.08 (10.05)	10:00	5.00 (4.53)	10:00	1.43 (1.30)	10:00	0.67 (0.60)
11:00	11.08 (10.05)	11:00	2.63 (2.39)	11:00	1.43 (1.30)	11:00	0.35 (0.32)
Total	**86.31 (78.30)**		**122.77 (111.37)**		**11.14 (10.10)**		**16.36 (14.84)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	31,502.79 (28,578.88)		**44,810.92 (40,651.83)**		**4,065.54 (3,688.20)**		**5,970.49 (5,416.34)**
Annual Combined Total	**86,349.74 (78,335.26)**						

Results are rounded where appropriate.

10.3.2.3 2036 Emissions

Emissions for year 2036 were calculated using the same methodology as the 2021 Baseline emissions, except with the vehicle age and corresponding fuel distribution equivalent to 2026 U.S. values. The vehicle and fuel distribution amongst this analysis year is consistent between the Future No-Build and Proposed Project.

Future No-Build Conditions

The 2036 Future No-Build GHG traffic emissions were determined via MOVES as a basis for comparison to the Proposed Project. The 2036 Future No-Build had 18,235 maximum morning and evening hourly vehicles (8,350 AM and 9,885 PM). Additionally, the modelled average speed by segment was approximately 29.8 mph (48.0 km/h). **Table 10-26** illustrates the expected annual GHG emissions of 88,177.94 short tons (79,993.77MT) for the 2036 Future No-Build conditions. Refer to **Tables A-8** and **A-9** in **Appendix I.1 - Traffic Data for GHG Analysis** for specific details of 2036 Future No-Build road segment data.

Proposed Project

The 2036 Proposed Project incorporated 18,519 aggregate hourly vehicles at approximately 35.4 mph (57.0 km/h). Refer to **Tables A-10** and **A-11** in **Appendix I.1 - Traffic Data for GHG Analysis** for specific details of the 2036 Proposed Project road segment data. Fuel distribution/vehicle type changes were modified from 2026. For example, while passenger cars remain the same percentage of the overall volume (92.3%) from 2026 to 2036, the amount of gasoline vehicles decreases from 95.7% to 66.5%. In conjunction, the share of electric cars increases from 0.012% to 31.49%. Similarly, both transit buses and short haul trucks diesel usage are reduced in favour of gasoline and electric. Due to the fuel improvements, the increase in vehicles of nearly 46,500 per day from 2026 only increased GHG emissions incrementally as illustrated in **Table 10-27**.

The 2036 Proposed Project is predicted to emit 87,605 short tons (79,474 MT) of GHGs annually. As outlined in **Section 10.3.2.2: 2026 Emissions**, emissions are directly correlated mostly by four MOVES input parameters: distance travelled, volume of vehicles, vehicle/fuel type and distribution, and travelling speed. During the 2036 analysis year, the improvements to fuel and vehicle distribution offset an increase in traffic volume which resulted in minimal net GHG emissions variability from 2026 to 2036 for the Proposed Project (see **Tables 10-25** and **10-27**).

Table 10-26: 2036 Future No-Build Annual Emissions (CO_2e)

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	1.5 (1.36)	12:00 PM	9.97 (9.05)	12:00 AM	0.17 (0.15)	12:00 PM	0.96 (0.87)
01:00	0.89 (0.81)	01:00	10.78 (9.78)	01:00	0.10 (0.09)	01:00	1.03 (0.94)
02:00	0.60 (0.55)	02:00	11.47 (10.41)	02:00	0.07 (0.06)	02:00	1.10 (1.00)
03:00	0.53 (0.48)	03:00	13.19 (11.97)	03:00	0.06 (0.05)	03:00	1.27 (1.15)
04:00	1.24 (1.13)	04:00	14.19 (12.88)	04:00	0.14 (0.13)	04:00	1.36 (1.24)
05:00	9.68 (8.78)	05:00	14.85 (13.47)	05:00	1.08 (0.98)	05:00	1.42 (1.29)
06:00	12.56 (11.4)	06:00	14.32 (13.00)	06:00	1.40 (1.27)	06:00	1.37 (1.25)
07:00	13.99 (12.69)	07:00	13.46 (12.21)	07:00	1.56 (1.42)	07:00	1.29 (1.17)
08:00	14.04 (12.74)	08:00	10.16 (9.21)	08:00	1.57 (1.42)	08:00	0.97 (0.88)
09:00	12.41 (11.26)	09:00	8.01 (7.26)	09:00	1.39 (1.26)	09:00	0.77 (0.70)
10:00	11.65 (10.57)	10:00	5.23 (4.74)	10:00	1.30 (1.18)	10:00	0.50 (0.46)
11:00	11.65 (10.57)	11:00	2.75 (2.50)	11:00	1.30 (1.18)	11:00	0.26 (0.24)
Total	**90.75 (82.33)**		**128.38 (116.46)**		**10.14 (9.20)**		**12.32 (11.18)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	33,123.13 (30,048.84)		**46,857.17 (42,508.16)**		**3,700.12 (3,356.70)**		**4,497.51 (4,080.07)**
Annual Combined Total	**88,177.94 (79,993.77)**						

Results are rounded where appropriate.

Table 10-27: 2036 Proposed Project Annual Emissions (CO_2e)

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	1.54 (1.40)	12:00 PM	9.42 (8.54)	12:00 AM	0.17 (0.15)	12:00 PM	1.21 (1.10)
01:00	0.92 (0.83)	01:00	10.18 (9.23)	01:00	0.10 (0.09)	01:00	1.31 (1.19)
02:00	0.62 (0.56)	02:00	10.83 (9.83)	02:00	0.07 (0.06)	02:00	1.39 (1.26)
03:00	0.54 (0.49)	03:00	12.46 (11.30)	03:00	0.06 (0.05)	03:00	1.60 (1.45)
04:00	1.27 (1.16)	04:00	13.40 (12.16)	04:00	0.14 (0.13)	04:00	1.72 (1.56)
05:00	9.92 (9.00)	05:00	14.02 (12.72)	05:00	1.09 (0.99)	05:00	1.80 (1.63)
06:00	12.87 (11.68)	06:00	13.53 (12.27)	06:00	1.42 (1.28)	06:00	1.74 (1.58)
07:00	14.33 (13.00)	07:00	12.71 (11.53)	07:00	1.58 (1.43)	07:00	1.63 (1.48)
08:00	14.39 (13.05)	08:00	9.59 (8.70)	08:00	1.58 (1.43)	08:00	1.23 (1.12)
09:00	12.72 (11.54)	09:00	7.56 (6.86)	09:00	1.40 (1.27)	09:00	0.97 (0.88)
10:00	11.94 (10.83)	10:00	4.93 (4.48)	10:00	1.31 (1.19)	10:00	0.63 (0.57)
11:00	11.93 (10.83)	11:00	2.60 (2.36)	11:00	1.31 (1.19)	11:00	0.33 (0.30)
Total	**93.00 (84.37)**		**121.23 (109.98)**		**10.22 (9.27)**		**15.57 (14.12)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	33,943.98 (30,793.49)		**44,247.77 (40,140.95)**		**3,731.43 (3,385.10)**		**5,682.04 (5,154.67)**
Annual Combined Total	**87,605.22 (79,474.21)**						

Results are rounded where appropriate.

10.3.2.4 2046 Emissions

Emissions for year 2046 were calculated using the same methodology as the 2021 Baseline emissions, except with the vehicle age and corresponding fuel distribution equivalent to 2046 U.S. values. The vehicle and fuel distribution amongst this analysis year is consistent between the Future No-Build and Proposed Project.

Future No-Build Conditions

The 2046 Future No-Build GHG traffic emissions were determined via MOVES as a basis for comparison to the Proposed Project. The 2046 Future No-Build had 22,627 aggregate maximum hourly vehicles. Additionally, the modelled average speed by segment was approximately 26.8 mph (43.1 km/h). **Table 10-28** illustrates the expected annual GHG emissions of 88,835 short tons (80,590 MT) for the 2046 Future No-Build conditions. Refer to **Tables A-12** and **A-13** in **Appendix I.1 - Traffic Data for GHG Analysis** for specific details of 2046 Future No-Build road segment data.

Proposed Project

The 2046 Proposed Project included 23,781 aggregate hourly vehicles at approximately 37.4 mph (60.2 km/h). Refer to **Tables A-14** and **A-15** in **Appendix I.1 - Traffic Data for GHG Analysis** for specific details of the 2046 Proposed Project road segment data. Fuel distribution/vehicle type changes are modified from 2036. For example, gasoline passenger cars are reduced by 3.5% and allocated to electric cars. Additionally, transit buses reduce diesel by 16.9% and were replaced with 14.7% electric and 2.1% compressed natural gas (CNG) vehicles. Haul truck fuel distribution also decreased gasoline/diesel in favour of electric (16.2% short haul and 3.5% combo haul increase). Daily vehicle volumes are projected to increase by approximately 41,600 vehicles compared to 2036. However, because of continued fuel improvements, predicted GHG emissions decrease from 2036 as illustrated in **Table 10-29**.

The 2046 Proposed Project is predicted to emit 85,793 short tons (77,830 MT) of GHGs annually. As outlined in **Section 10.3.2.2: 2026 Emissions**, emissions are directly correlated mostly by four MOVES input parameters: distance travelled, volume of vehicles, vehicle/fuel type and distribution, and travelling speed. During the 2046 analysis year, continued improvements to fuel and vehicle distribution fully offset an increase in traffic volume which resulted in a net GHG emissions reduction from 2036 to 2046 for the Proposed Project (see **Tables 10-27** and **10-29**).

Table 10-28: 2046 Future No-Build Annual Emissions (CO_2e)

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	1.52 (1.37)	12:00 PM	10.06 (9.12)	12:00 AM	0.17 (0.15)	12:00 PM	0.96 (0.87)
01:00	0.90 (0.82)	01:00	10.87 (9.86)	01:00	0.10 (0.09)	01:00	1.04 (0.94)
02:00	0.61 (0.55)	02:00	11.57 (10.49)	02:00	0.07 (0.06)	02:00	1.10 (1.00)
03:00	0.53 (0.48)	03:00	13.30 (12.07)	03:00	0.06 (0.05)	03:00	1.27 (1.15)
04:00	1.25 (1.14)	04:00	14.31 (12.98)	04:00	0.14 (0.13)	04:00	1.36 (1.24)
05:00	9.75 (8.85)	05:00	14.97 (13.58)	05:00	1.08 (0.98)	05:00	1.43 (1.30)
06:00	12.66 (11.48)	06:00	14.45 (13.11)	06:00	1.40 (1.27)	06:00	1.38 (1.25)
07:00	14.09 (12.78)	07:00	13.57 (12.31)	07:00	1.56 (1.42)	07:00	1.29 (1.17)
08:00	14.15 (12.83)	08:00	10.24 (9.29)	08:00	1.57 (1.42)	08:00	0.98 (0.89)
09:00	12.51 (11.34)	09:00	8.07 (7.32)	09:00	1.39 (1.26)	09:00	0.77 (0.70)
10:00	11.74 (10.65)	10:00	5.27 (4.78)	10:00	1.30 (1.18)	10:00	0.50 (0.46)
11:00	11.73 (10.65)	11:00	2.78 (2.52)	11:00	1.30 (1.18)	11:00	0.26 (0.24)
Total	**91.44 (82.95)**		**129.47 (117.45)**		**10.14 (9.20)**		**12.35 (11.20)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	33,373.80 (30,276.24)		**47,255.25 (42,869.29)**		**3,699.59 (3,356.22)**		**4,506.53 (4,088.26)**
Annual Combined Total	**88,835.17 (80,590.01)**						

Results are rounded where appropriate.

Table 10-29: 2046 Proposed Project Annual Emissions (CO_2e)

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	1.55 (1.41)	12:00 PM	9.05 (8.21)	12:00 AM	0.19 (0.17)	12:00 PM	1.07 (0.97)
01:00	0.92 (0.84)	01:00	9.78 (8.88)	01:00	0.11 (0.10)	01:00	1.15 (1.05)
02:00	0.62 (0.56)	02:00	10.41 (9.44)	02:00	0.07 (0.07)	02:00	1.23 (1.11)
03:00	0.54 (0.49)	03:00	11.97 (10.86)	03:00	0.07 (0.06)	03:00	1.41 (1.28)
04:00	1.28 (1.16)	04:00	12.88 (11.69)	04:00	0.15 (0.14)	04:00	1.52 (1.38)
05:00	9.98 (9.05)	05:00	13.47 (12.22)	05:00	1.20 (1.09)	05:00	1.59 (1.44)
06:00	12.95 (11.75)	06:00	13.00 (11.79)	06:00	1.56 (1.42)	06:00	1.53 (1.39)
07:00	14.41 (13.08)	07:00	12.21 (11.08)	07:00	1.74 (1.58)	07:00	1.44 (1.31)
08:00	14.47 (13.13)	08:00	9.22 (8.36)	08:00	1.74 (1.58)	08:00	1.09 (0.99)
09:00	12.79 (11.60)	09:00	7.27 (6.59)	09:00	1.54 (1.40)	09:00	0.86 (0.78)
10:00	12.01 (10.89)	10:00	4.74 (4.30)	10:00	1.45 (1.31)	10:00	0.56 (0.51)
11:00	12.00 (10.89)	11:00	2.50 (2.27)	11:00	1.45 (1.31)	11:00	0.29 (0.27)
Total	**93.52 (84.84)**		**116.52 (105.70)**		**11.27 (10.22)**		**13.74 (12.47)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	34,135.48 (30,967.22)		**42,528.81 (38,581.53)**		**4,112.51 (3,730.81)**		**5,015.92 (4,550.37)**
Annual Combined Total	**85,792.71 (77,829.93)**						

Results are rounded where appropriate.

10.3.2.5 2074 Emissions

Emissions for 2074 were calculated using the same methodology as the 2021 Baseline emissions, but with the vehicle age and corresponding fuel distribution set to mirror U.S. values in 2060 and scaled to 2074 as described in **Section 10.1.3: Traffic Emissions Methodology.** The vehicle and fuel distribution amongst this analysis year is consistent between the Future No-Build and Proposed Project. The evaluation of emissions for 2074 included three land use/population growth scenarios (2074-Low, 2074-Medium, and 2074-High). The Low and Medium growth scenarios are described together, but the High growth will be described separately due to it being an outlier from a vehicle volume and GHG emissions perspective.

Future No-Build Conditions (Low and Medium Growth)

The 2074-Low and Medium growth Future No-Build GHG traffic emissions were determined via MOVES as a basis for comparison to the Proposed Project. The 2074-Low and Medium growth Future No-Build ranged from 25,781 to 34,259 aggregate maximum hourly vehicles. Additionally, the modelled average speed ranged from approximately 25.4 mph (40.9 km/h) for the 2074-Low to 21.0 mph (33.8 km/h) for the 2074-Medium volume. **Tables 10-30** and **10-32** illustrates the expected annual GHG emissions of 106,355 short tons (96,483 MT) and 147,539 short tons (133,845 MT) for the 2074-Low and Medium growth Future No-Build conditions, respectively. Refer to **Tables A-16**, **A-17**, **A-20** and **A-21** in **Appendix I.1 - Traffic Data for GHG Analysis** for specific details of 2074-Low and Medium Future No-Build road segment data.

Proposed Project (Low and Medium Growth)

The 2074-Low and Medium growth Proposed Project ranged from 36,311 to 39,792 aggregate hourly vehicles at approximately 34.4 mph (55.4 km/h) and 34.6 mph (55.7 km/h), respectively. Refer to **Tables A-18**, **A-19**, **A-22** and **A-23** in **Appendix I.1 - Traffic Data for GHG Analysis** for specific details of the 2074-Low and Medium growth Proposed Project road segment data. Fuel distribution/vehicle type changes are modified from 2046. For example, gasoline passenger cars are reduced by 7.3% and allocated to electric cars (increase of 7.9% from 2046; Ethanol 85 allocation is reduced by 0.6%). Additionally, transit buses reduce diesel by 14.8% and were replaced with 10.9% CNG and 3.9% gasoline vehicles. Haul truck fuel distribution remained relatively constant. Daily vehicle volumes between 2074-Low and Medium growth are projected to increase by 109,160 on average when compared to 2046. Although the fuel and distribution continued to improve, the volume increase outweighs the fuel updates. As a result, the predicted GHG emissions increase from 2046 as illustrated in **Tables 10-31 and 10-33**.

The 2074-Low and Medium growth Proposed Project are predicted to emit 123,938 short tons (112,435 MT) and 128,575 short tons (116,642 MT) of GHGs, respectively. As outlined in **Section 10.3.2.2: 2026 Emissions**, emissions are directly correlated mostly by four MOVES input parameters: distance travelled, volume of vehicles, vehicle/fuel type and distribution, and travelling speed. During the 2074-Low and Medium analysis year, continued improvements to fuel and vehicle distribution coincided with an increase in traffic volume, resulting in a net GHG emissions increase from 2046 to 2074 for the Proposed Project (see **Tables 10-29**, **10-31** and **10-33**).

Table 10-30: 2074-Low Future No-Build Annual Emissions

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	2.04 (1.85)	12:00 PM	11.42 (10.36)	12:00 AM	0.16 (0.14)	12:00 PM	0.93 (0.85)
01:00	1.21 (1.10)	01:00	12.34 (11.20)	01:00	0.09 (0.08)	01:00	1.01 (0.92)
02:00	0.82 (0.74)	02:00	13.13 (11.91)	02:00	0.06 (0.06)	02:00	1.07 (0.97)
03:00	0.71 (0.65)	03:00	15.10 (13.70)	03:00	0.05 (0.05)	03:00	1.23 (1.12)
04:00	1.69 (1.53)	04:00	16.25 (14.74)	04:00	0.13 (0.12)	04:00	1.33 (1.20)
05:00	13.12 (11.90)	05:00	17.00 (15.42)	05:00	1.00 (0.91)	05:00	1.39 (1.26)
06:00	17.03 (15.45)	06:00	16.40 (14.88)	06:00	1.30 (1.18)	06:00	1.34 (1.22)
07:00	18.96 (17.20)	07:00	15.41 (13.98)	07:00	1.45 (1.31)	07:00	1.26 (1.14)
08:00	19.03 (17.26)	08:00	11.63 (10.55)	08:00	1.45 (1.32)	08:00	0.95 (0.86)
09:00	16.82 (15.26)	09:00	9.17 (8.32)	09:00	1.29 (1.17)	09:00	0.75 (0.68)
10:00	15.79 (14.32)	10:00	5.98 (5.43)	10:00	1.21 (1.09)	10:00	0.49 (0.44)
11:00	15.79 (14.32)	11:00	3.15 (2.86)	11:00	1.21 (1.09)	11:00	0.26 (0.23)
Total	**123.00 (111.58)**		**146.97 (133.33)**		**9.40 (8.53)**		**12.01 (10.90)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	44,895.22 (40,728.31)		**53,643.85 (48,664.94)**		**3,430.56 (3,112.15)**		**4,384.97 (3,977.99)**
Annual Combined Total	**106,354.60 (96,483.39)**						

Results are rounded where appropriate.

Table 10-31: 2074-Low Proposed Project Annual Emissions

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	2.22 (2.01)	12:00 PM	12.76 (11.57)	12:00 AM	0.32 (0.29)	12:00 PM	1.71 (1.55)
01:00	1.32 (1.19)	01:00	13.79 (12.51)	01:00	0.19 (0.17)	01:00	1.85 (1.68)
02:00	0.89 (0.81)	02:00	14.67 (13.31)	02:00	0.13 (0.12)	02:00	1.97 (1.79)
03:00	0.77 (0.70)	03:00	16.87 (15.31)	03:00	0.11 (0.1)	03:00	2.26 (2.05)
04:00	1.83 (1.66)	04:00	18.16 (16.47)	04:00	0.27 (0.24)	04:00	2.44 (2.21)
05:00	14.27 (12.95)	05:00	18.99 (17.23)	05:00	2.08 (1.89)	05:00	2.55 (2.31)
06:00	18.52 (16.80)	06:00	18.33 (16.62)	06:00	2.70 (2.45)	06:00	2.46 (2.23)
07:00	20.62 (18.71)	07:00	17.22 (15.62)	07:00	3.00 (2.72)	07:00	2.31 (2.10)
08:00	20.70 (18.78)	08:00	12.99 (11.79)	08:00	3.01 (2.74)	08:00	1.74 (1.58)
09:00	18.30 (16.60)	09:00	10.24 (9.29)	09:00	2.66 (2.42)	09:00	1.37 (1.25)
10:00	17.18 (15.58)	10:00	6.69 (6.06)	10:00	2.50 (2.27)	10:00	0.90 (0.81)
11:00	17.17 (15.58)	11:00	3.52 (3.19)	11:00	2.50 (2.27)	11:00	0.47 (0.43)
Total	**133.80 (121.38)**		**164.23 (148.99)**		**19.49 (17.68)**		**22.04 (20.00)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	48,835.19 (44,302.59)		**59,945.35 (54,381.57)**		**7,112.12 (6,452.01)**		**8,045.40 (7,298.67)**
Annual Combined Total	**123,938.05 (112,434.84)**						

Results are rounded where appropriate.

Table 10-32: 2074-Medium Future No-Build Annual Emissions

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	2.60 (2.35)	12:00 PM	16.28 (14.77)	12:00 AM	0.29 (0.26)	12:00 PM	1.61 (1.46)
01:00	1.54 (1.40)	01:00	17.60 (15.96)	01:00	0.17 (0.16)	01:00	1.74 (1.58)
02:00	1.04 (0.94)	02:00	18.72 (16.98)	02:00	0.12 (0.10)	02:00	1.85 (1.68)
03:00	0.91 (0.82)	03:00	21.53 (19.53)	03:00	0.10 (0.09)	03:00	2.12 (1.93)
04:00	2.15 (1.95)	04:00	23.17 (21.02)	04:00	0.24 (0.22)	04:00	2.29 (2.07)
05:00	16.70 (15.15)	05:00	24.23 (21.98)	05:00	1.86 (1.68)	05:00	2.39 (2.17)
06:00	21.68 (19.67)	06:00	23.38 (21.21)	06:00	2.41 (2.19)	06:00	2.31 (2.09)
07:00	24.14 (21.90)	07:00	21.97 (19.93)	07:00	2.68 (2.43)	07:00	2.17 (1.97)
08:00	24.23 (21.98)	08:00	16.58 (15.04)	08:00	2.69 (2.44)	08:00	1.64 (1.48)
09:00	21.42 (19.43)	09:00	13.07 (11.86)	09:00	2.38 (2.16)	09:00	1.29 (1.17)
10:00	20.10 (18.24)	10:00	8.53 (7.74)	10:00	2.23 (2.03)	10:00	0.84 (0.76)
11:00	20.10 (18.23)	11:00	4.49 (4.08)	11:00	2.23 (2.03)	11:00	0.44 (0.40)
Total	**156.59 (142.06)**		**209.55 (190.10)**		**17.39 (15.78)**		**20.68 (18.76)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	57,156.73 (51,851.77)		**76,486.01 (69,387.02)**		**6,347.45 (5,347)**		**7,548.70 (6,848.08)**
Annual Combined Total	**147,538.89 (133,845.19)**						

Results are rounded where appropriate.

Table 10-33: 2074-Medium Proposed Project Annual Emissions

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	2.34 (2.12)	12:00 PM	13.32 (12.08)	12:00 AM	0.29 (0.26)	12:00 PM	1.75 (1.58)
01:00	1.39 (1.26)	01:00	14.39 (13.06)	01:00	0.17 (0.16)	01:00	1.89 (1.71)
02:00	0.94 (0.85)	02:00	15.31 (13.89)	02:00	0.12 (0.11)	02:00	2.01 (1.82)
03:00	0.82 (0.74)	03:00	17.61 (15.98)	03:00	0.10 (0.09)	03:00	2.31 (2.09)
04:00	1.93 (1.75)	04:00	18.95 (17.19)	04:00	0.24 (0.22)	04:00	2.48 (2.25)
05:00	15.03 (13.64)	05:00	19.82 (17.98)	05:00	1.86 (1.69)	05:00	2.60 (2.36)
06:00	19.51 (17.7)	06:00	19.13 (17.35)	06:00	2.42 (2.19)	06:00	2.51 (2.28)
07:00	21.72 (19.7)	07:00	17.97 (16.30)	07:00	2.69 (2.44)	07:00	2.36 (2.14)
08:00	21.8 (19.78)	08:00	13.56 (12.30)	08:00	2.70 (2.45)	08:00	1.78 (1.61)
09:00	19.27 (17.48)	09:00	10.69 (9.70)	09:00	2.39 (2.17)	09:00	1.40 (1.27)
10:00	18.09 (16.41)	10:00	6.98 (6.33)	10:00	2.24 (2.03)	10:00	0.91 (0.83)
11:00	18.08 (16.41)	11:00	3.67 (3.33)	11:00	2.24 (2.03)	11:00	0.48 (0.44)
Total	**140.92 (127.84)**		**171.40 (155.49)**		**17.47 (15.85)**		**22.47 (20.39)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	51,434.67 (46,660.80)		**62,561.56 (56,754.96)**		**6,375.71 (5,783.95)**		**8,203.29 (7,441.91)**
Annual Combined Total	**128,575.23 (116,641.62)**						

Results are rounded where appropriate.

Future No-Build Conditions (High Growth)

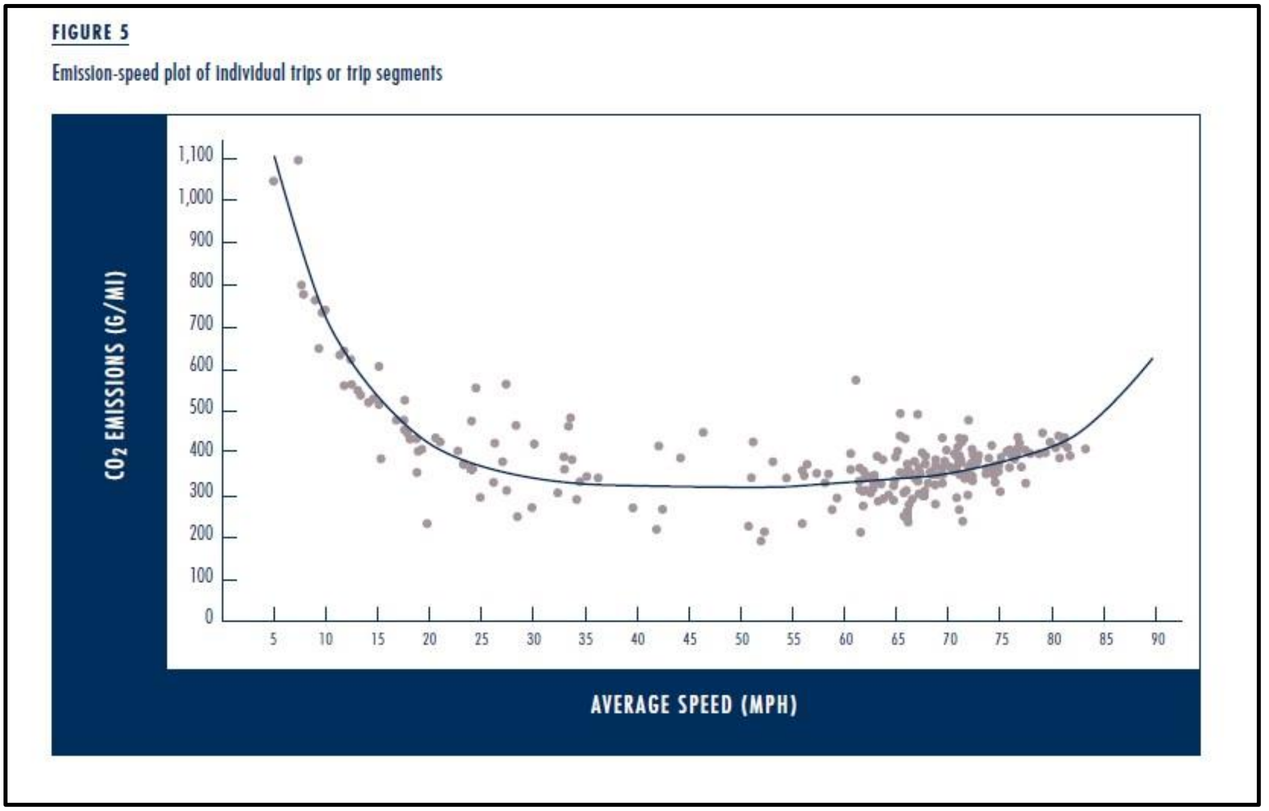
The 2074-High growth Future No-Build GHG traffic emissions, like the others described, are provided for comparison purposes to the Proposed Project only. The 2074-High Future No-Build had 64,763 aggregate maximum hourly vehicles. Additionally, the modelled average speed by segment was approximately 11.9 mph (19.1 km/h). **Table 10-34** illustrates the expected annual GHG emissions of 507,401 short tons (460,307 MT) for the 2074-High Future No-Build conditions. Refer to **Tables A-24** and **A-25** in **Appendix I.1 - Traffic Data for GHG Analysis** for specific details of 2074-High Future No-Build road segment data.

Proposed Project (High Growth)

The 2074-High growth Proposed Project is an outlier when compared to other 2074 growth scenarios and analysis years, due to the primary MOVES inputs consisting of higher projected traffic volumes and lower average travel speeds. The 2074-High growth Proposed Project included 141,400 aggregate hourly vehicles at approximately 24.6 mph (39.6 km/h). Note that nearly half (~48.8%) of the projected volumes are along road segments with an average speed less than 21.0 mph (33.8 km/h) with over 18,400 vehicle less than 15 mph (24.1 km/h). Refer to **Tables A-26** and **A-27** in **Appendix I.1 - Traffic Data for GHG Analysis** for specific details of the 2074-High Proposed Project road segment data.

As illustrated in Olaverri-Monreal et al (2018), CO_2 emissions tend to be highest at the extremes when compared to vehicle speed, and larger vehicles have more variability (Olaverri-Monreal et al., 2018). The travel in year 2074-High growth is projected to generate more emissions due to an increased number of large vehicles (6,162 more large vehicles [single short haul and combo short haul] from 2046 to 2074-High). In conjunction with more vehicles, the average speed is much lower for the Future 2074-High scenario as previously described, which correlates to more GHG emissions as illustrated in **Figure 10-3**. When the speeds are approximately 15 mph (24.1 km/h) or less, emissions increase rapidly. For comparison purposes, approximately 13% of the 2074-High Proposed Project volume is less than 15 mph (24.1 km/h). However, 69% of the Future 2074-High No-Build volume operates at or around 5 mph (8 km/h).

Figure 10-3: Greenhouse Gas Emissions vs Average Speed (Barth & Boriboonsomsin, 2009))



While the percentage of electric vehicles is anticipated to increase, the number of CNG buses is also projected to increase by nearly 20% throughout the life of the project. CNG for heavy-duty vehicles produces more CO_2 emissions than diesel fuel by approximately 22% (CTCN 2011). Additionally, the percentage of diesel single haul and combo haul trucks were still 59.3% and 95% diesel fuel, respectively.

Daily vehicle volumes associated with 2074-High growth are projected to increase by over 925,000 compared to 2046. Although the fuel distribution continues to improve, the volume increase outweighs the fuel updates. As a result, the predicted GHG emissions increase from 2046 as illustrated in **Table 10-35**. Due to the projected increases in vehicle volumes and general reduction of average speeds, the overall expected GHG emissions by 2074-High Proposed Project increase. The 2074-High growth Proposed Project are predicted to emit 581,210 short tons (527,266 MT) of GHGs annually.

Table 10-34: 2074-High Future No-Build Annual Emissions

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	9.85 (8.94)	12:00 PM	51.54 (46.76)	12:00 AM	1.04 (0.94)	12:00 PM	5.38 (4.88)
01:00	5.85 (5.31)	01:00	55.71 (50.54)	01:00	0.62 (0.56)	01:00	5.82 (5.28)
02:00	3.95 (3.58)	02:00	59.27 (53.77)	02:00	0.42 (0.38)	02:00	6.19 (5.62)
03:00	3.44 (3.12)	03:00	68.17 (61.84)	03:00	0.36 (0.33)	03:00	7.12 (6.46)
04:00	8.15 (7.39)	04:00	73.35 (66.54)	04:00	0.86 (0.78)	04:00	7.66 (6.95)
05:00	63.43 (57.54)	05:00	76.72 (69.60)	05:00	6.7 (6.08)	05:00	8.01 (7.27)
06:00	82.32 (74.68)	06:00	74.03 (67.16)	06:00	8.7 (7.89)	06:00	7.73 (7.01)
07:00	91.64 (83.14)	07:00	69.55 (63.09)	07:00	9.68 (8.79)	07:00	7.26 (6.59)
08:00	92.00 (83.46)	08:00	52.49 (47.62)	08:00	9.72 (8.82)	08:00	5.48 (4.97)
09:00	81.32 (73.77)	09:00	41.38 (37.54)	09:00	8.59 (7.80)	09:00	4.32 (3.92)
10:00	76.33 (69.25)	10:00	27.01 (24.50)	10:00	8.07 (7.32)	10:00	2.82 (2.56)
11:00	76.31 (69.23)	11:00	14.22 (12.90)	11:00	8.06 (7.32)	11:00	1.49 (1.35)
Total	**594.59 (539.40)**		**663.43 (601.86)**		**62.83 (57.00)**		**69.28 (62.85)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	217,025.51 (196,882.47)		**242,152.30 (219,677.14)**		**22,934.56 (20,805.90)**		**25,288.75 (22,941.59)**
Annual Combined Total	**507,401.12 (460,307.10)**						

Results are rounded where appropriate.

Table 10-35: 2074-High Proposed Project Annual Emissions

Road Segments (Combined)				Intersections (Combined)			
AM Hours	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**	**AM Hours**	**Tonne/hr (MT/hr)**	**PM Hours**	**Tonne/hr (MT/hr)**
12:00 AM	10.11 (9.17)	12:00 PM	52.26 (47.41)	12:00 AM	2.42 (2.20)	12:00 PM	12.73 (11.55)
01:00	6.00 (5.45)	01:00	56.48 (51.24)	01:00	1.44 (1.30)	01:00	13.76 (12.48)
02:00	4.05 (3.68)	02:00	60.10 (54.52)	02:00	0.97 (0.88)	02:00	14.64 (13.28)
03:00	3.53 (3.20)	03:00	69.12 (62.7)	03:00	0.84 (0.77)	03:00	16.84 (15.27)
04:00	8.36 (7.58)	04:00	74.37 (67.47)	04:00	2.00 (1.82)	04:00	18.12 (16.43)
05:00	65.05 (59.01)	05:00	77.79 (70.57)	05:00	15.58 (14.13)	05:00	18.95 (17.19)
06:00	84.42 (76.59)	06:00	75.06 (68.09)	06:00	20.21(18.34)	06:00	18.28 (16.59)
07:00	93.99 (85.26)	07:00	70.52 (63.97)	07:00	22.50 (20.42)	07:00	17.18 (15.58)
08:00	94.35 (85.59)	08:00	53.23 (48.29)	08:00	22.59 (20.49)	08:00	12.96 (11.76)
09:00	83.40 (75.66)	09:00	41.95 (38.06)	09:00	19.97 (18.12)	09:00	10.22 (9.27)
10:00	78.28 (71.02)	10:00	27.38 (24.84)	10:00	18.74 (17.01)	10:00	6.68 (6.05)
11:00	78.26 (71.00)	11:00	14.42 (13.08)	11:00	18.74 (17.00)	11:00	3.51 (3.19)
Total	**609.80 (553.20)**		**672.69 (610.26)**		**146.01 (132.46)**		**163.86 (148.65)**
Annual	**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**		**Tonne/yr (MT/yr)**
	222,575.42 (201,917.26)		**245,532.60 (222,743.69)**		**53,294.99 (48,348.46)**		**59,807.38 (54,256.41)**
Annual Combined Total	**581,210.39 (527,265.82)**						

Results are rounded where appropriate.

10.3.2.6 Traffic Emissions Summary

As illustrated in **Table 10-36**, the Proposed Project produces higher emissions throughout most of the analysis timeline. However, by 2046, emissions are reduced despite the maximum hourly volume increase of over 5,200 vehicles as a result of the anticipated fuel distribution/vehicle type changes and generally higher average speeds by 2046. Overall, 2074 emissions of the Proposed Project increase as the vehicle volume increase. Unlike the Future No-Build, the emissions increase at a lower rate than the volume for the 2074-Low and 2074-Medium scenario. The 2074-Low scenario increases volume by 52.7% from 2046, but emissions rise by only 44.5% (2074-Medium 63.1% volume increase and 49.9% emissions rise). Again, the 2074-High scenario is an outlier as the emissions increase substantially from 2046 (591.4% emissions [494.6% volume]). Average speeds are approximately 10 mph (16.1 km/h) lower than other 2074 scenarios, which causes GHG emissions to increase at a faster rate. While the 2074 predicted emissions suggest higher GHG potential, it should be noted that these estimates are heavily influenced by the volume of vehicles. The estimated volumes described throughout this study are based on information known today. As a result, the emission estimates are conservative. Moving into the future, emission factors, refinements to the MOVES model and adjustments to expected volumes are likely to improve. **Table 10-36** provides the overall annual GHG emissions. However, the Proposed Project will add roadway capacity, induce demand and allow more east-west accessibility to drivers throughout the island (See **Chapter 7: Transportation and Mobility**). The demand on the current coastal road is expected to lessen and gridlock to be reduced. Ultimately, vehicle fuel distribution is expected to improve over time with the introduction of more electric vehicles and improved emissions on per vehicle basis and general average speeds to increase, reducing congested traffic.

Table 10-36: Overall GHG Emissions by Year

Year	Scenario	AM Tonne/yr (MT/yr)	PM Tonne/yr (MT/yr)	Total Tonne/yr (MT/yr)
		CO2e Emissions		
2021	Baseline	24,532.27 (22,255.33)	41,299.82 (37,466.61)	65,832.09 (59,721.94)
2026	No-Build	29,656.05 (26,903.55)	45,534.75 (41,308.48)	75,190.80 (68,212.03)
	Proposed Project	35,568.33 (32,267.09)	50,781.41 (46,068.17)	86,349.74 (78,335.26)
2036	No-Build	36,823.26 (33,405.54)	51,354.68 (46,588.24)	88,177.94 (79,993.77)
	Proposed Project	37,675.40 (34,178.59)	49,929.81 (45,295.62)	87,605.22 (79,474.21)
2046	No-Build	37,037.40 (33,632.46)	51,761.77 (46,957.55)	88,835.17 (80,590.01)
	Proposed Project	38,247.99 (34,698.03)	47,544.73 (43,131.90)	85,792.71 (77,829.93)
2074	No-Build – Low Scenario	48,325.78 (43,840.46)	58,028.82 (52,642.93)	106,354.60 (96,483.39)
	Proposed Project – Scenario	55,947.30 (50,754.60)	67,990.75 (61,680.24)	123,938.05 (112,434.84)
	No-Build – Medium Scenario	63,504.18 (57,610.09)	84,034.71 (76,235.10)	147,538.89 (133,845.19)
	Proposed Project – Medium Scenario	57,810.38 (52,444.75)	70,764.85 (64,196.87)	128,575.23 (116,641.62)
	No-Build – High Scenario	239,630.07 (217,688.37)	267,441.05 (242,618.73)	507,401.12 (460,307.10)
	Proposed Project – High Scenario	275,870.41 (250,265.72)	305,339.98 (277,000.10)	581,210.39 (527,265.82)

AM and PM include through traffic and intersection traffic combined

While the emissions have a general upward trend throughout the project life, the Proposed Project has a lower impact when compared to the Future No-Build. Intermediate Years 2036 and 2046 demonstrate that the Proposed Project would produce fewer emissions than the Future No-Build. This is also true for the 2074-Medium and 2074-High scenarios. These improvements gradually increase ranging from a reduction of 572.7 short tons (519.6 MT) in 2026 to 18,249.3 short tons (17,203.6 MT) for the 2074-Medium scenario.

As previously described, there are situations that were analysed which show lower emissions from a Future No-Build, but those are limited, and the Proposed Project in those cases allows for more vehicles. Overall, the Proposed Project demonstrates that traffic emissions would be incrementally higher over the life of the project but allows for a much more substantial number of vehicles, limit congestion along the coastal road and flexibility along the Proposed Project.

10.3.2.7 Annual Carbon Sequestration Loss

Ecosystem services from carbon sequestration include the total tonnes of CO_2e sequestered each year (tCO_2e/yr) based on the 2020 Cayman Islands Ecosystem Accounting. The anticipated Proposed Project impacts on annual carbon sequestration loss are evaluated within **Section 13.5: Project Impacts**. The total anticipated carbon sequestration rate is 424.2 tCO_2e/yr.

10.3.2.8 Solar Array

The proposed solar array is estimated to be built in a later phase of the Proposed Project, with a starting date of 2046. The monetised costs and benefits of the proposed solar array are part of an overall CBA conducted for this project. The anticipated main savings benefits include (1) electricity cost savings to users, and (2) carbon emissions reductions. Based on the preliminary solar array assessment, the anticipated total CO_2 (GHG) reduction equates to 566,644 MT over the expected 30-year lifetime of the facility, where the anticipated annual average carbon savings include the carbon disbenefit in year 2045 of manufacturing solar canopy and battery components as well as the estimated fuel production savings tabulated over 30 years.

Therefore, the benefits of a solar panel canopy (in terms of avoiding diesel fuel costs and carbon emissions) is expected to exceed the investment cost of purchasing, installing, and operating the proposed solar facility. For additional explanation on the monetised costs and benefits of the proposed solar array and associated documentation of detailed assumptions, refer to **Chapter 16: Cost-Benefit Analysis** and **Appendix E – Shortlist [Alternatives] Evaluation: Attachment J – Cost-Benefit Analysis – Assessment of Alternatives**.

10.3.3 Summary of Lifecycle Emissions

This section is an overall summary of potential Proposed Project emissions (**Table 10-37)**. Emissions include construction tailpipe, peat and habitat removal, bulk material emissions operational traffic emissions from 2026, 2036, 2046, 2074-Low, 2074-Medium, and 2074-High, and annual carbon sequestration loss. The solar array, anticipated to reduce emissions, is also included. Comparison and monetisation of the GHG emissions between the Proposed Project and No-Build condition is included within **Chapter 16: Cost-Benefit Analysis**. Based on the results of the CBA, the Proposed Project results in an overall emissions benefit under the 2074-Medium scenario and disbenefit under the 2074-Low scenario. The 2074-High scenario was not evaluated within the CBA.

Table 10-37: Summary of GHG Emissions Throughout Life of Project

Emission Type	Metric Tonnes (CO_2e)	Short Tons (CO_2e)
Construction Tailpipe	32,388	35,702
Peat/Habitat*	73,589	81,118
Bulk Material Total	97,953	107,974
Traffic Baseline	59,722	65,832
Traffic 2026	78,335	86,350
Traffic 2036	79,474	87,605
Traffic 2046	77,830	85,793
Traffic 2074 Low	112,435	123,938
Traffic 2074 Medium	116,642	128,575
Traffic 2074 High	527,266	581,210
Annual Carbon Sequestration Loss	424.2	467.6
Solar Array	-566,644	-624,618

* Only carbon stock is included within this line-time. Annual carbon sequestration loss is listed as a separate line-item.

10.4 Mitigation Measures

Several mitigation considerations are described in this section. Each measure is categorised as outlined in **Table 10-38**. Overall, there are four general resources which include: peat, vehicle-related measures, vegetation, and construction-related. Specific measures are outlined in **Tables 10-39** and **10-40**.

Table 10-38: Characterisation of Quantitative and Qualitative Mitigation

Characterisation	Description	Quantitative Measure or Definition of Qualitative Categories
Magnitude	The size or degree of the effects compared against baseline conditions or reference levels, and other applicable measurement parameters (i.e., standards, guidelines, objectives) – See reporting thresholds in **Section 10.1.1**.	**Negligible (N) |** No anticipated GHG emissions **Low (L) |** Less than 25,000 MT **Medium (M) |** Great than 25,000 MT, less than 100,000 MT **High (H) |** Greater than 100,000 MT
Geographic Extent	The geographic area over which the effects are likely to be measurable	**Limits of Disturbance (LOD) |** Occurs within the Proposed Project LOD **Outside Limits of Disturbance (OLOD) |** Occurs outside of the Proposed Project LOD, but within the identified Study Area
Timing	Considers when the environmental effect is expected to occur. Timing considerations are noted in the evaluation of the environmental effect, where applicable or relevant.	**Not Applicable (NA) |** Seasonal variations are not likely to change the effect **Applicable (A) |** Seasonal aspects may affect the outcome of the effect
Duration	The time period over which the effects are likely to last	**Short-Term (ST) |** The effect is reversible at the end of construction works **Medium-Term (MT) |** The effect is reversible within a defined length of time **Long-Term (LT) |** The effect is reversible over an extended length of time
Frequency	The rate of recurrence of the effects (or conditions causing the effect)	**Once (O) |** Effects occur once **Occasional (Oc) |** Effects that could occur randomly throughout the project lifetime **Regular (R) |** Effects can occur at regular intervals through construction and/or operation **Continuous (C) |** Effects are continuous throughout construction and operation
Reversibility	The degree to which the effects can or would be reversed (typically measured by the time it will take to restore the environmental attribute or feature)	**Reversible (R) |** The baseline conditions would recover to their standard after the construction works are completed **Partially Reversible (PR) |** Mitigation can return the baseline conditions **Not Reversible (NR) |** Mitigation cannot guarantee a return to baseline conditions

10.4.1 Construction Phase

The construction phase includes five general mitigation considerations that are focused on peat and vegetation removal, construction material use, construction machinery updating and potential engine retrofitting. Except for material use, it is anticipated that the potential construction phase impacts would be temporary in nature. The impacts range from short-term to long-term.

Design related mitigation considerations, such as geogrids to limit peat removal, are included within **Section 6.8: Phasing and Constructability.** This section focuses on mitigation considerations for excavated peat. Peat removal can be minimised/recycled by applying on-site utilisation. On-site activities may be able to utilise peat in construction or reinstatement, such as restoration of staging areas, road verges, and peatland/mangrove ecosystems. This approach minimises displacement of peat to reduce carbon loss and impacts to ecosystem functioning. Additionally, transportation-related emissions are minimised due to fewer truck transferring peat from the construction site. Utilisation of peat for construction and/or site restoration may be limited due to its variable physical characteristics (e.g., acrotelm vs. catotelm). This approach reduces potential GHG impacts the most.

Off-site ecosystem restoration utilisation is another potential peat removal mitigation consideration related to peat removal. Excavated waste peat may be usable off-site for wetland restoration projects. Peat suitability for off-site ecosystem restoration purposes may vary, depending on physical characteristics and/or other environmental risks associated with translocated organic material. The magnitude of transportation-related emissions is dependent on distance between excavation and project site(s).

Off-site recycling is a third potential peat removal mitigation consideration. Peat may be spread on land for agricultural benefit, and/or utilised in a soil blend. This provides agricultural benefits (e.g., enhanced soil fertility). However, equipment and/or transportation-related emissions generated from delivery and application of peat across agricultural lands may negate any potential carbon benefits arising from additional soil organic matter inputs.

Minimisation of vegetation clearing where possible is a good method to limit potential GHG impacts. See **Chapter 13: Terrestrial Ecology** for construction sequencing and mitigation considerations.

Implementation of efficient bulk construction materials could reduce the potential impact of GHGs. This could reduce the need to repair/replace road segments more often, which results in lower indirect emissions. Similarly, application of recycled/reused materials also minimises indirect GHG emissions. The application of stronger, more robust materials that require less maintenance, repair and refurbishment could reduce indirect impacts as well. In addition, utilising and maintaining construction equipment that includes the most up-to-date emission controls would minimise short-term tailpipe emissions. As an alternative, engines could be retrofitted to meet lower GHG tailpipe emission standards. The construction phase potential mitigation considerations are summarized in **Table 10-39**.

Table 10-39: Construction Phase Mitigation Measures

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Peat</td><td rowspan="2">Removal of peat during construction</td><td rowspan="2">Onsite/offsite utilisation, restoration and/or recycling</td><td>L/M</td><td>LOD/ OLOD</td><td>NA</td><td>MT</td><td>Oc</td><td>NR</td><td rowspan="2">Low to Medium residual effect</td><td rowspan="2">Significant, depending on the measures implemented.</td></tr>
<tr><td colspan="6">Assuming mitigation measures are applied, there would be low to medium impacts to on and offsite depending on the measure applied. On-site activities to utilise peat in construction or reinstatement, such as restoration of staging areas, road verges, and peatland/mangrove ecosystems would reduce impact. Offsite recycling is also viable but will be minimal mitigation.

Removal will occur within and Outside the LOD.

Seasonal variability is unlikely to significantly modify the rate of peat removal.

The impact would be medium term and as restoration will not fully occur immediately, but impacts would only result during construction.

The frequency would be Occasional but restricted to the construction schedule.

The impact is not reversible as the site would be stabilized over time through restoration but would not return to baseline conditions due to the construction of the Proposed Project.</td></tr>
<tr><td>Vegetation</td><td>Removal of vegetation during construction</td><td>Minimise vegetation clearing; Re-vegetate temporary construction areas</td><td colspan="8">See Chapter 13: Terrestrial Ecology for additional information.</td></tr>
</table>

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Construction</td><td rowspan="2">Material Use</td><td rowspan="2">Ensuring efficient use of materials (i.e., “right-sizing”)</td><td>M</td><td>LOD</td><td>NA</td><td>ST</td><td>R</td><td>NR</td><td rowspan="2">Medium residual effect</td><td rowspan="2">Significant - mitigation efforts could minimise the amount of bulk materials but would not eliminate to a negligible level</td></tr>
<tr><td colspan="6">Bulk material emissions are anticipated to be a Medium magnitude of impact. The use of more efficient material will lower emissions in general, however the emissions would likely remain at the Medium magnitude.

The activity would occur within the LOD.

There is no expected seasonal variability.

The impact of incorporating efficient material would be short-term.

The frequency would be regular but restricted to the construction schedule.

The impact is not reversible as the site would be stabilized over time through restoration but would not return to baseline conditions due to the construction of the roadway.</td></tr>
</table>

Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Construction	Material Use	Utilising sustainable materials	M	LOD	NA	LT	R	NR	Medium residual effect	Significant - mitigation efforts could minimise the amount of bulk materials but would not eliminate to a negligible level
			Bulk material emissions are anticipated to be a Medium magnitude of impact. The use of sustainable materials would lower future emissions; however, the overall emissions would likely remain at the Medium magnitude. The activity would occur within the LOD. There is no expected seasonal variability. The impact of incorporating sustainable material would be long-term. The frequency would be regular but restricted to the construction schedule. The impact is not reversible as the site would be stabilized over time through restoration but would not return to baseline conditions due to the construction of the roadway.							

Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Construction	Machinery	Maintaining machinery frequently or replacing with newer machinery or retrofit engines	N/L	LOD	NA	ST	R	NR	Negligible to Low	Not Significant
			Construction machinery is anticipated to emit low magnitude of GHG emissions. Assuming mitigation measures are applied, there would be a low to negligible impact. The activity would occur within the LOD. There is no expected seasonal variability. The impact of incorporating newer machinery would be short term but would not adversely affect the project area. The frequency would be regular but restricted to the construction schedule. The impact is not reversible as the site would be stabilized over time through restoration but would not return to baseline conditions due to the construction of the roadway.							

10.4.2 Operation Phase

The operation phase includes two traffic-related mitigation measures. The measures are vehicular fleet composition and traffic movement optimisation; both of which are permanent and long-term. Through governmental legislation, the promotion for transition to more electric and lower emission vehicles or other means would reduce project vehicle emissions. The operations phase potential mitigation considerations are summarized in **Table 10-40**.

See **Chapter 13: Terrestrial Ecology** for potential mitigation measure considerations for annual carbon sequestration loss.

The solar array canopy is an anticipated net-positive in GHG emissions, minimising the overall Proposed Project emissions over the lifetime.

Table 10-40: Operation Phase Mitigation Measures

Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Vehicle Traffic	General Traffic	Vehicular fleet composition	M	LOD/ OLOD	A	LT	C	NR	Medium	Significant - This would continue to reduce tailpipe emissions throughout the operational phase of the project and operational traffic related GHG emissions would be lowered.
			Implementation of new legislation toward cleaning vehicles sooner than assumed for the Proposed Project could reduce emissions to a Medium magnitude. The activity would occur within and Outside the LOD. There is minimal seasonal variability but may result from increased tourism and travel during the dry season. Vehicle emissions incrementally vary from month to month. The impact of incorporating stricter vehicle emissions than assumed for the Proposed Project would be long-term. The frequency would be continuous but would be a net positive for the island and result in an improvement from the Proposed Project emissions calculated in **Section 10.3**. The impact of the mitigation is not reversable. However, the institution of the mitigation would reduce emissions beyond the Proposed Project.							

Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Vehicle Traffic	General Traffic	Traffic movement optimisation	N	LOD/ OLOD	A	LT	C	NR	None	Significant - This would continue to reduce tailpipe emissions throughout the operational phase of the project and traffic impacts would be lowered.
			Assuming mitigation measures are applied, there would be a minor impact to the site. Further traffic configuration would promote less congestion and smoother travel beyond the Proposed Project than assumed for Proposed Project and would reduce emissions for future years. The activity would occur within and Outside the LOD. There is minimal seasonal variability. Vehicle emissions incrementally vary from month to month. The impact of incorporating stricter vehicle emissions than assumed for the Proposed Project would be long term but would not adversely affect the project area. The frequency would continuous but would be a net positive for the island and result in an improvement from the Proposed Project emissions calculated in **Section 10.3**. The impact of the mitigation is not reversable. However, the institution of the mitigation would reduce emissions beyond the Proposed Project.							

10.4.3 Summary of GHG Mitigation Measures

Mitigation measure considerations during construction primarily consist of peat and vegetation removal, construction material use, construction machinery updating and potential engine retrofitting. Design related mitigation measures to limit peat removal are included within **Chapter 6: Proposed Project – Engineering Features**, the GHG section focuses on mitigation measures for excavated peat, including onsite/offsite utilisation, restoration and/or recycling. Vegetation removal mitigation considerations are included in **Chapter 13: Terrestrial Ecology**. Construction material (bulk material) mitigation considerations include the efficient use of materials (i.e., "right-sizing") and utilising sustainable materials. Construction machinery emission can be minimised through maintaining machinery frequently or replacing with newer machinery or retrofit engines.

Mitigation considerations during operation include traffic-related mitigation measures. Through governmental legislation, the promotion for transition to more electric and lower emission vehicles could reduce project vehicle emissions. The optimization of traffic movements on the Island could also reduce project vehicle emissions. See **Chapter 7: Transportation and Mobility** for additional details regarding traffic operations.

Additional information regarding implementation, responsibilities for implementation, any monitoring and reporting, and actions for non-compliance will be included as part of the separate EMP. Due to the phased development of the project, a review of the mitigation measures and design solutions will be continually evaluated during the design, construction, and operation phases to allow for successful mitigation.

11 Geo-Environmental

Geo-environmental processes on Grand Cayman and within the EWA EIA study area contribute to sourcing potable water to residents and support natural resources. The term "geo-environmental" refers to natural elements in the subsurface such as geology, soils, peat deposits, karst, groundwater, and freshwater lens resources. Applicable governmental standards were reviewed, and the baseline conditions were assessed for the island's geo-environmental processes.

As stated in the ToR, the construction of the proposed roadway may impact the natural geo-environmental process and existing resources. This can lead to effects on the island's natural resources and sources of potable water. These effects could be reduced if best management practices are applied during construction, such as use of low-impact construction equipment. In addition, operation impacts could be reduced by implementing best management design features that will effectively treat and remove stormwater as well as maintain natural hydrological flow patterns by the use of bridges and culverts at designated locations along the corridor, plus developing spill response plans.

The assessment of the geo-environmental process will consider effects from changes to freshwater lenses, pollution from stormwater runoff, groundwater quality, and impact on resources such as peat, groundwater, freshwater lenses, and underlying aquifers.

This Geo-environmental chapter of the ES focuses on the following:

- Describes the methodology for geo-environmental assessments;
- Establishes baseline conditions within the Study Area;
- Identifies the potential benefits and adverse impacts due to the project, including construction and operation phases;
- Assesses the significance of these potential impacts; and,
- Offers avoidance, minimisation, and mitigation considerations for the Proposed Project's potential negative geo-environmental impacts.

This chapter assesses the effects of the Proposed Project described in **Chapter 6: Proposed Project – Engineering Features**. Baseline Conditions, which equate to Existing Conditions, are established to demonstrate the geo-environmental environment of Grand Cayman.

11.1 Assessment Methodology

This section describes the methodology used to assess geo-environmental elements during the EIA process. This methodology is in compliance with the ToR and follows established Cayman Islands law and international standards and practices, which are described in the following subsections.

11.1.1 Applicable Standards and Guidelines

The WAC, under the Water Authority Act (2022 Revision), is charged with the management, control, and protection of water resources. The Water Authority Act (2022 Revision) 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.

The WAC in the Cayman Islands is a utility and a regulatory agency that operates a central sewerage system and regulates onsite wastewater treatment systems. The WAC also operates a central water supply system that uses reverse osmosis treatment of saline groundwater. In addition, the WAC regulates the construction and use of water supply wells.

The Water Authority Law, passed in 1982, placed controls on extraction from freshwater lenses. Three large, exploitable freshwater lenses occur on Grand Cayman. Formerly widespread was the pumping and trucking of water from such lenses, and some trucking of water continues. Historically some other (smaller) freshwater lenses on Grand Cayman have been lost due to excessive pumping and/or groundwater contamination.

Section 19, part (2) of the Development and Planning Regulations of the Cayman Islands (2020 Revision) indicates that, "Strict conditions shall be imposed to ensure that the water in the lens shall not be contaminated by the development or by the effluent therefrom and that the quantity of water used will not deplete the lens to the disadvantage of the existing users."

The WAC operates four reverse osmosis plants on Grand Cayman. The Cayman Water Company (a private water utility) operates three reverse osmosis plants to supply users in the western part of Grand Cayman.

The WAC regulates the treatment and disposal of wastewater. There is no central sewage system in the Study Area and wastewater in the project area is treated by septic tanks for small developments and aerobic treatment units for larger developments. Treated effluent is discharged into effluent disposal wells. The WAC issues the specifications for effluent disposal wells. The NRA manages stormwater disposal, typically excess stormwater is disposed via stormwater drainage wells. In the Cayman Islands the term effluent is typically used for disposal wells for the disposal of treated effluent, and stormwater wells for the disposal of stormwater.

11.1.2 Data Sources Evaluated

11.1.2.1 Desktop Review

A source of geological and hydrogeological information for this assessment was the 2022 book by Dr. Brian Jones titled, Geology of the Cayman Islands. Also, the WAC provided two reports prepared for the CIG by Richards and Dumbleton International (RDI), dated August 1975 and November 1980, which contain data on the depth and areal extent of the freshwater lenses. The Hydrogeological Survey of Grand Cayman y (a 1:50,000-scale map) contains data that were also evaluated. The data sources utilised are listed in the References section of this document.

On December 13, 2023, the WAC provided information related to groundwater conditions in the vicinity of the Lower Valley Freshwater Lens and the North Side Freshwater Lens (see **Figure 11-13**). This consisted of monitoring data from various periods within the overall time of 1982 to 2013, including water level data, electrical resistivity profiles, maps of monitoring wells and domestic wells, a technical paper about the Lower Valley reverse osmosis plant, and several case studies in which well owners were assisted by the WAC with recommendations regarding development of private groundwater supplies. The groundwater information from the WAC primarily pertains to salinity levels as they relate to maintaining water supply for potable and non-potable purposes.

11.1.2.2 Stakeholder Consultation

Coordination with the WAC has occurred throughout this study to obtain relevant information regarding available geo-environmental information for Grand Cayman, including collected data, soil mapping, and technical reports for the Lower Valley and North Side fresh groundwater lenses.

11.1.2.3 Desktop Studies and Field Visits

Desktop studies were conducted, including a freshwater lens assessment and historical canal impact assessment on the freshwater lenses (**Section 11.2.6: Desktop Studies**) to qualitatively assess the reported locations of freshwater lenses and assess potential unconfined aquifer impacts associated with the development of canals based on literature review.

In addition to the desktop studies, the following site visits were conducted by the study team for ground truthing and reconnaissance on the island, which are summarized in **Appendix J.7 – Hydrology and Drainage Field Effort**:

- First site visit in July 2023
- Second site visit in May 2024

11.1.3 Constraints and Limitations

The following limitations and constraints apply to the assessment of geo-environmental features and resources in this chapter:

- Limited survey within the Proposed Project corridor does not provide the level of detail necessary for final design calculation and analysis.
- Limited geotechnical investigation within the Proposed Project corridor does not provide the level of detail necessary for final design calculation and analysis. The available geotechnical information consisted of test pit logs from a previous investigation along a different alignment. No ground investigations at depth (i.e., boreholes) were carried out at that stage due to limited access.
- Lack of water quality data that informs other types of potential freshwater contamination with other pollutants.
- Limited understanding of the actual hydrogeological dynamics within the karst formation due to limited geotechnical investigation on the dimensions, connections, and levels of unconfined aquifers.

The elements will be completed as part of detailed design of the Proposed Project, which will occur once the EIA is complete.

11.1.4 Assessment of Geo-Environmental Impacts

The overall quantitative and qualitative evaluation relies on the UK Department for Transport “Transport Analysis Guidance” (WebTAG), Unit A3. Quantitative variables, such as distance, length, increase of imperviousness, and volume of peat removal were used to inform the qualitative evaluation. The significance of the effect of geo-environmental impacts is dependent on both the sensitivity of the resource and the magnitude of the impact at the resource. In addition, construction and operation impacts were further assessed using multiple variables to determine the magnitude of impact, the importance/sensitivity of the impacted resources, and the significance of the impact.

11.1.4.1 Baseline Conditions

Baseline conditions within the study area were assessed to evaluate the geo-environmental processes and identify potential resources. Published data and publicly available information was reviewed to develop the baseline conditions considerations. Information on geo-environmental factors, including peat, underlying aquifers, groundwater, and freshwater lenses was collected and analysed to define geo-environmental processes and is described in **Section 11.2: Baseline Conditions**.

11.1.4.2 Desktop Studies and Field Assessments

Various studies were conducted to provide additional information regarding geo-environmental aspects to better assess potential impacts and are included in **Section 11.2.6: Desktop Studies**. In addition, a groundwater mounding analysis was completed to assess the impact of the Proposed Project on the Lower Valley and North Side freshwater lenses, which is included in **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**. Two field assessments were completed to identify existing geo-environmental elements within the study area, observe natural resources such as peat, and other items of interest, such as quarries. Findings are included in **Section 11.2: Baseline Conditions**.

11.1.4.3 Quantitative Impact Assessment

A quantitative analysis was completed to assess potential impacts on the identified receptors, including freshwater lenses, brackish groundwater, and peat and is included in **Section 11.3.1: Quantitative Impact Assessment**. Potential impacts assessed included the following:

- Change in the quality of groundwater and aquifers
- Removal of peat

11.1.4.4 Qualitative Assessment Methodology

The qualitative assessment for Geo-environmental is based upon the UK Department for Transport's "Transport Analysis Guidance Unit A3: Environmental Impact Appraisal" (WebTAG). The most applicable category for Geo-environmental impacts is "Impacts on the Water Environment". The completed qualitative assessment incorporates WebTAG Section 10 of Unit A3: Environmental Impact Appraisal as appropriate. The qualitative assessment also incorporates the March 2020 DMRB LA 113 as appropriate.

There are three steps in the WebTAG qualitative assessment. The first step is to determine the importance (or value) of features, which includes very high, high, medium, and low. The second step is to determine the magnitude of impact (positive or negative), which includes major, moderate, and minor and also negligible. The third step is to determine the overall assessment score based on the results of Steps 1 and 2. As shown in **Table 11-1**, the assessment scores are based on the magnitude of impact and the importance of the water environment feature and can include large adverse, moderate adverse, slight adverse, and neutral. More information on the qualitative assessment methodology for geo-environmental can be found in the **Appendix E - Shortlist Evaluation: Attachment E – Geo-Environmental – Assessment of Alternatives**.

Table 11-1: Assessment Score by Resource

Magnitude of Impact*	Importance of Water Environment Features			
	Very High	High	Medium	Low
Major Negative	Large adverse**	Large adverse	Moderate adverse	Slight adverse
Moderate Negative	Large adverse	Moderate adverse	Slight adverse	Neutral
Minor Negative	Moderate adverse	Slight adverse	Neutral	Neutral
Negligible	Slight adverse	Neutral	Neutral	Neutral

**Identified impacts were adverse, therefore beneficial impacts are not shown within the table*
***Very Large and Large Adverse were merged to be consistent with the 7-point qualitative scale for the Appraisal Summary Table*
Source: WebTAG Unit A3, Environmental Impact Appraisal, Table 15, November 2023

11.1.4.5 Potential Construction and Operation Impacts

Impacts were further assessed on the identified geo-environmental receptors/resources based on construction-related and operation-related activities, including:

- Likelihood
- Certainty
- Type
- Temporal
- Magnitude
- Sensitivity
- Significance

Each impact to an identified geo-environmental receptor/resource was evaluated, assigned a sensitivity value, analysed the magnitude of change on the receptor/resource, and assigned a rating for the significance of the effects. The significance of the effects was determined by the sensitivity of the relevant geo-environmental feature and the magnitude of change as a consequence of the Proposed Project. In terms of geo-environmental, the key types of effects analysed relate to a change in the quality of groundwater and aquifers and the removal of peat.

The sensitivity of geo-environmental receptors/resources analysed for this assessment was related to the importance of the features. The magnitude of change on geo-environmental receptors is considered independently from the sensitivity since it considers potential impacts along with the inclusion of suggested mitigation considerations.

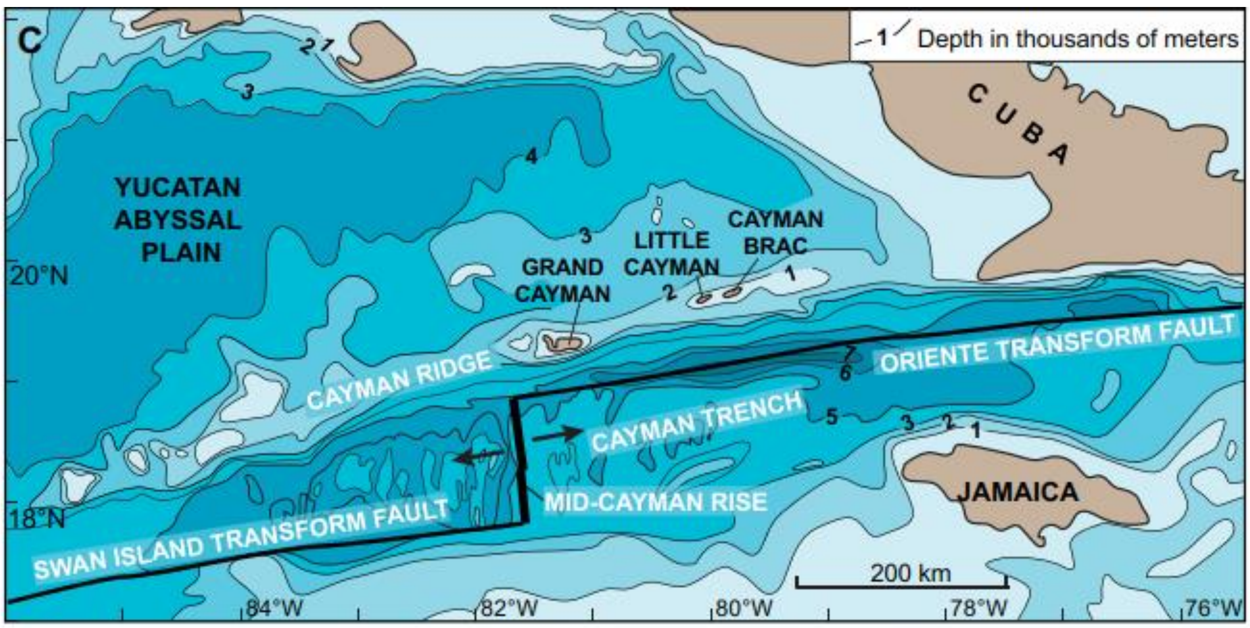
11.2 Baseline Conditions

11.2.1 Geology

Grand Cayman can be categorized as a low-lying island environment. A recent estimate of the maximum land surface elevation at Grand Cayman is approximately 56 ft (17 m) above sea level, from the book "Geology of the Cayman Islands" by Dr. Jones, which was published by Springer in 2022.

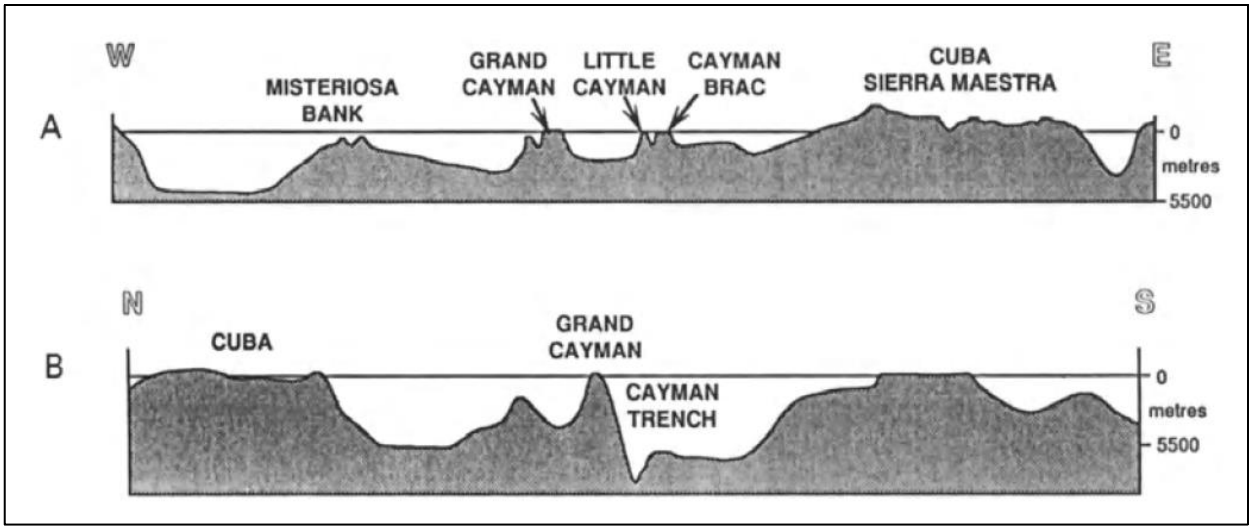
Grand Cayman is located on the Cayman Ridge, which forms the southern margin of the North American plate. The Cayman Ridge is a block uplifted above the surrounding seafloor, which is bounded by dipping fault planes. The region is tectonically active because the Cayman Islands are near the Oriente Transform Fault and the Mid-Cayman Rise. A map of the Caribbean area and a cross section showing the Cayman Ridge are in **Figures 11-1 and 11-2**, respectively. **Figure 11-1** is from Ren (2017). **Figure 11-2** is from Jones (1994).

Figure 11-1: Map of the Caribbean Area



Source: Ren (2017)

Figure 11-2: Cross section of Cayman Ridge. (A) Location of Grand Cayman on Cayman Ridge (B) Cayman Trench



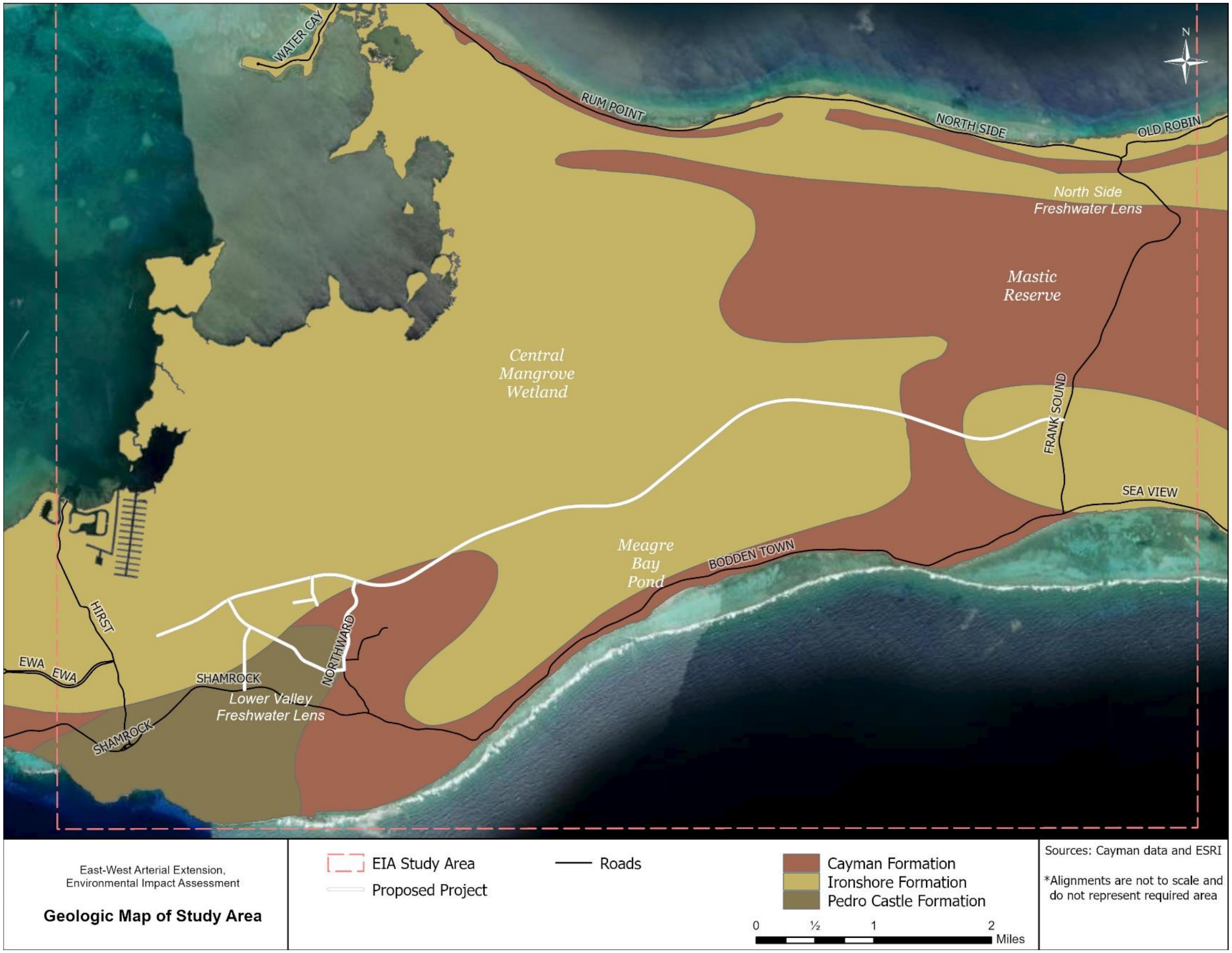
Source: Jones (1994)

Carbonate rock up to 30 million years old is exposed on Grand Cayman. The carbonate thickness is at least 1,316 ft (401 m) based on deep well data described in the book "Geology of the Cayman Islands" (2022) by Dr. Jones. The carbonates rest on older bedrock, having been formed during cycles of sea level change. During high stands of sea level, carbonate deposition occurred. In low stands of sea level, previously formed carbonates were eroded and weathered. The strata dip toward the west at up to five degrees. Unconformities occur between the mapped formations, which represent periods of erosion.

The Bluff Group is a stratigraphic name that includes the following geologic units: from deepest (oldest) to youngest (shallowest): the Brac Formation, the Cayman Formation, and the Pedro Castle Formation. Although the Brac Formation is stratigraphically within the Bluff Group beneath the Cayman Islands, the Brac Formation specifically is not exposed at the island of Grand Cayman. (Jones, 2022)

A geologic map that also shows the Proposed Project is included in **Figure 11-3**. The Cayman Formation immediately underlies the Proposed Project in two relatively small areas in the eastern and western extent. It consists of relatively hard, microcrystalline dolostone containing the mineral dolomite (calcium magnesium carbonate). Dolostone in the Cayman Islands is dolomitized limestone in which magnesium ions from seawater have replaced calcium ions. The calcium percentage in the rock increases from the peripheral part of Grand Cayman to the interior-most areas of the island. The gradual dolomitization by seawater occurred during the Miocene, Pliocene, and Pleistocene Epochs.

Figure 11-3: Geologic Map of the Study Area



The thickness of the Cayman Formation reaches 492 ft (150 m). Exposed Cayman Formation may have an irregular surface from karst landscape development, and it commonly has caves. The rock is extensively jointed, and many joints are solution-widened. Further, joints and other openings may be filled with breccia composed of carbonate rock fragments.

The Proposed Project overlies the Pedro Castle Formation in the Will T area. The Pedro Castle Formation overlies the Cayman Formation and outcrops mainly in the southernmost part of Grand Cayman, which is called Lower Valley. The Pedro Castle Formation is up to 70.5 ft (21.5 m) thick in the western part of Grand Cayman and 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. The Ironshore Formation underlies a majority of the Proposed Project and is the surficial geologic unit in most of western Grand Cayman. It's thickness ranges from a thin veneer to 29 ft (9 m) and consists of friable, poorly consolidated reef limestone, calcarenite, and oolitic limestone.

During the July 2023 and May 2024 field assessments, exposed bedrock formations were observed in the CMW area (**Figure 11-4**), EWA western terminus (**Figure 11-5**), Will T Road area (**Figures 11-6 and 11-7**), the quarries (**Figure 11-8**), and the Mastic Trail area (**Figures 11-9**). Crevices were observed in the region's bedrock (**Figure 11-10**). As indicated in the published mapping, carbonate rocks were observed exposed in outcrops and are documented in the following figures (**Figures 11-4, 11-5, 11-6, 11-9, and 11-10**).

Figure 11-4: Bedrock Outcrop in the CMW Area (July 2023)

Figure 11-5: Bedrock Outcrop within Western Terminus of the EWA (May 2024)

Figure 11-6: Exposed Bedrock in Cleared Area off Will T Road (May 2024)

Figure 11-7: Fossilized Shells in Bedrock at Quarry (May 2024)

Figure 11-8: Broken Rock Used as a Livestock Fence in Will T Area (May 2024)

Figure 11-9: Exposed Bedrock along Mastic Trail (July 2023)

Figure 11-10: Crevice in the Bedrock along the Mastic Trail (July 2023)

11.2.2 Soils

Soils are generally thin on Grand Cayman. The sediments in the extensive mangrove wetlands have a particular sequence, which is described as transgressive by Woodroffe (1981). The sequence records the gradual submergence of the island in the Holocene Epoch.

The basal unit has a crust that formed on rock during subaerial conditions predating the marine transgression. 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 organic content of the peat ranges from 50 to 80 percent, and it is 80 to 90 percent water as a percentage of wet weight. Exposed soil strata in a cleared construction site off Will T was observed during the May 2024 field assessment (**Figure 11-11**). Note that this soil horizon may have been disturbed during the house construction.

Figure 11-11: Exposed Soil Strata off Will T Road (May 2024)

The NRA provided plans and a subsurface profile for Section 2 of the East-West Extension (dated 2008). NRA provided similar information for a portion of Section 3 (dated 2014). The subsurface profiles trial pit data is included in **Appendix E - Shortlist Evaluation: Attachment E – Geo-Environmental – Assessment of Alternatives**. The spacing between most of the trial pits was 300 ft (91 m), although the spacing was smaller in some areas. The trial 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 trial pits encountered a layer of soil up to about 1 ft (0.3 m) thick on top of bedrock. Resting on this thin soil (or directly on top of bedrock) was a peat layer. The thickness of peat ranged from about 1 ft (0.3 m) to 14 ft (4.3 m). Several trial pits encountered the water table at, or just below the land surface.

For this assessment it was anticipated that the subsurface area would be excavated below the limits of weak materials, such as peat and carbonate-derived residuum, and then filled with load bearing materials to construct the Proposed Project. Actual foundation approaches will be determined in detailed design. Karst landscape conditions including voids may also influence the project designs and construction, especially in areas where proposed bridge or structure foundations are bearing on rock. Liquefaction of soils is another consideration that may occur due to tectonic activity (see **Section 11.2.1: Geology**).

11.2.3 Peat

Peat has historically been connected to climate change as it has been determined to sequester GHGs. Peat is primarily 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 typically contain carbonate minerals, and the presence of molluscs are rare. During the July 2023 and May 2024 field assessments, a section of peat was observed in conjunction with the mangroves north of the active quarry area (**Figure 11-12**).

Figure 11-12: Peat in Mangroves North of the Quarry Located Directly Northeast of Meagre Bay Pond (July 2023)

Mangrove-derived peat deposits underlie most of the mangrove swamps and cover the bedrock in many areas of Grand Cayman. Much of the peat is less than 3 ft (1 m) thick, but locally may be as thick as 20 ft (6 m). It is anticipated that peat underlies a portion of the Proposed Project based on the subsurface profile for Section 2 of the East-West Extension (dated 2008) and a portion of Section 3 (dated 2014). The thickness of peat in the 2008 and 2014 trial pits ranged from about 1 ft (0.3 m) to 14 ft (4 m). It should be noted that the 2008 and 2014 subsurface profiles do not encompass the entire study area and assumptions had to be made in estimation of peat volumes for the Proposed Project. Additional subsurface studies will be conducted as needed for the Proposed Project during detailed design.

For the roadway construction, peat and other unsuitable materials may need to be removed and replaced with aggregate to create a load-bearing foundation. The aggregate material may be mined from the existing authorised commercial quarries on Grand Cayman. In August 2018, the WAC estimated that there are approximately 32 million yd^3 (24.3 million m^3) of aggregate in the authorised commercial quarries. An alternative to removing peat and replacing with aggregate is to elevate sections of the proposed roadway using bridges and other design options. Additional information regarding potential bridges and hydrologic features can be found in **Chapter 6: Proposed Project - Engineering Features** and **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**.

11.2.4 Hydrogeology

The three largest, usable freshwater lenses on Grand Cayman are the Lower Valley Lens, the North Side Lens, and the East End Lens. Of these, the Lower Valley Lens is the smallest and the East End Lens is the largest. The main freshwater lenses currently existing within the EIA study area are the Lower Valley Lens and the North Side Lens. Existing roads, specifically Shamrock Road and Northward Road, and the Proposed Project overlay the Lower Valley Lens. The North Side Lens is located north of the eastern extent of the Proposed Project. A geologic map depicting the freshwater lenses and the Proposed Project is included in **Figure 11-13**. The freshwater lens assessment is in **Section 11.2.6: Desktop Studies**.

The source of the natural freshwater on Grand Cayman is almost entirely precipitation that contains a chloride concentration of 7 to 13.5 mg/l, based on information from the book, "Geology of the Cayman Islands" (2022) by Dr. Jones. Precipitation recharges the lenses by rapid flow through discontinuities in the bedrock during rainstorms. Recharge also occurs by slow infiltration through the unsaturated zone.

Freshwater occurs in lens-shaped bodies beneath topographic highs in the Bluff Group as an unconfined aquifer in the fractured carbonate rock. The unconfined aquifer is hydraulically connected with the ocean, and the water table elevation is typically less than 1.5 ft (0.5 m) above mean sea level. Because of the high permeability of the karst rock, surface streams are absent, and the water table gradient is low. Underneath the freshwater zone is a thick, brackish water zone that transitions from fresh to saline water. The freshwater zone has a chloride concentration less than or equal to 600 milligrams per litre (mg/l). In the brackish zone it is 600 to 19,000 mg/l. The saline zone has a chloride concentration of at least 19,000 mg/l. Tidal oscillations generate mixing of brackish and fresh water. The semi-diurnal tide range is 0.7 ft (0.2 m), and the seasonal fluctuation is 1.6 ft (0.5 m).

Based on the Ghyben–Herzberg ratio, for each 3.3 ft (1 m) of fresh water in an unconfined aquifer above sea level, there is 131.2 ft (40 m) of fresh water in the aquifer below sea level. In the Cayman Islands, an idealized lens configuration is not completely met because the extensively fractured bedrock aquifers cause the shapes of the lenses to change.

During the July 2023 and May 2024 field assessments, groundwater was observed in the quarry area. Excavation areas were filled with groundwater almost up to the existing ground level. The depth below the water table of the quarries varies. The older quarries were excavated in the 12 to

14 ft (3.7 to 4.3 m) range, and the commercial quarries reach depths up to 50 ft (15.2 m). See **Section 11.2.5: Quarries** and **Figure 11-14** for more information on quarries within the study area.

The portion of the CMW that could be observed from the north end of the quarry was mostly covered with pools of water at the surface level and was populated with mangrove trees. Refer to the Terrestrial Ecology Assessment of Alternatives Document for further details regarding the CMW and low-density mangrove areas.

Figure 11-13: Hydro-Geological Map of the Study Area

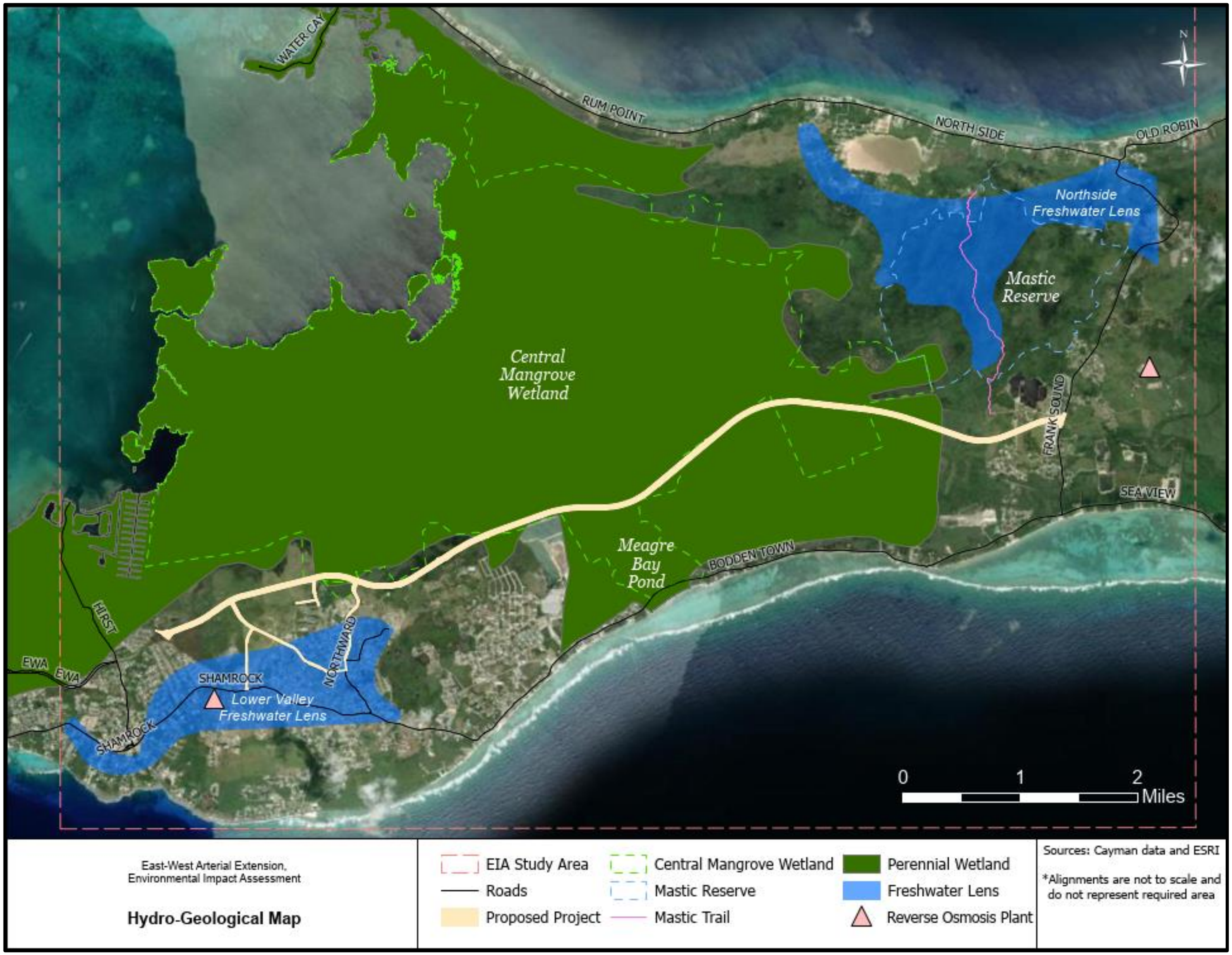
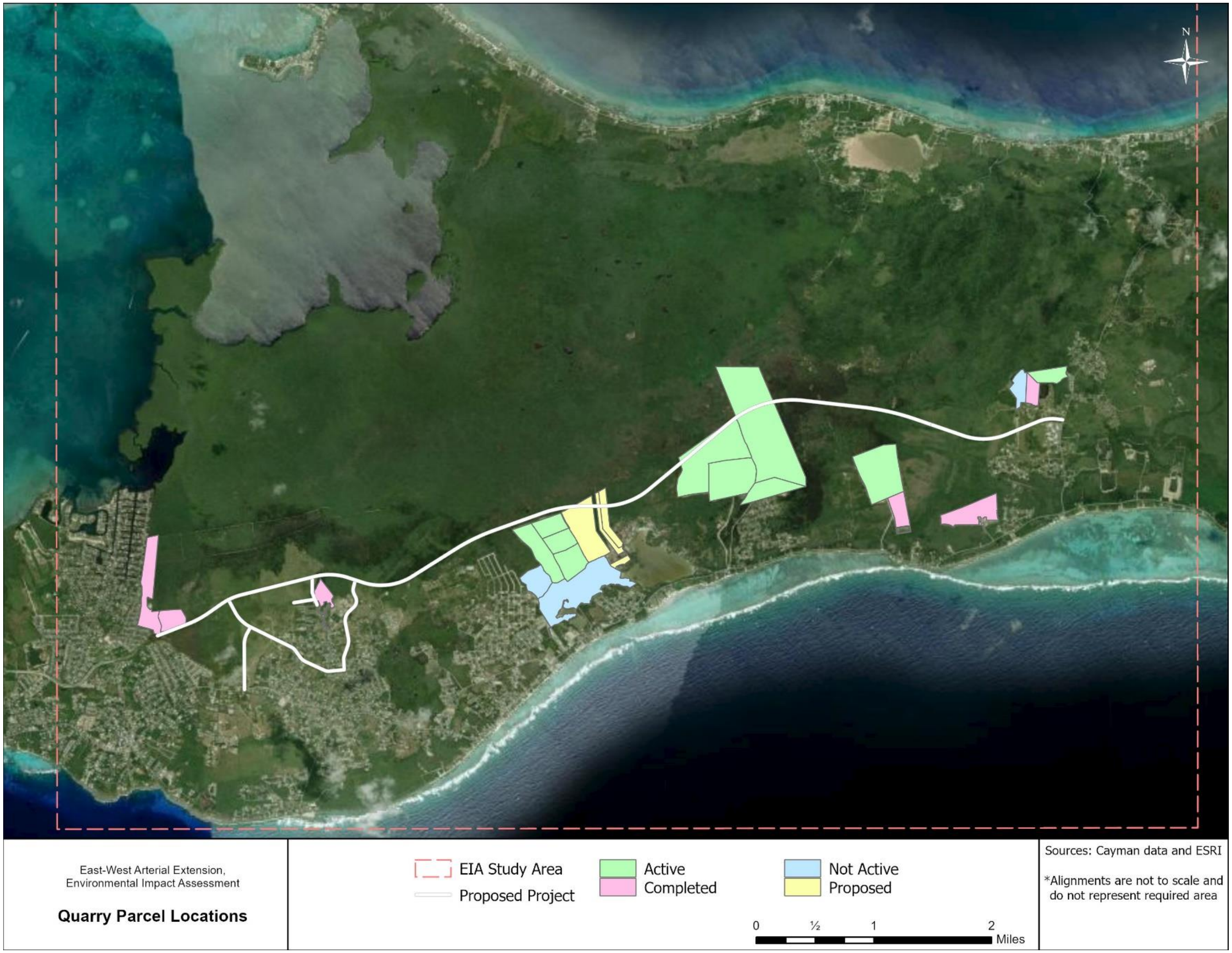


Figure 11-14: Quarry Locations within the EIA Study Area



11.2.5 Quarries

Based on coordination with the NRA, WAC, and DoE, there are a total of 17 quarries within the EIA study area, including six active, six completed, three not active, and two proposed quarries, encompassing a total of 22 parcels. In August 2018, the WAC estimated that there are approximately 32 million yd^3 (24.3 million m^3) of aggregate in the authorised commercial quarries. The Proposed Project is located directly adjacent to existing water-filled, rock quarries and crosses through two proposed quarries. In addition, the Proposed Project crosses land that contain two active quarries. Quarry locations are shown in **Figure 11-14**.

Based on the estimated aggregate quantities for the Proposed Project (**Appendix F.7.1 – Excellent Fit Construction Cost Estimate** and **Appendix I.2 – Bulk Materials GHG Analysis**), the Proposed Project requires an estimated maximum of 10-15% of the available aggregate within authorised commercial quarries.

Quarries represent potentially more direct pathways into the karst aquifer, especially where karst voids may have been connected to the surface as a result of mining or hydrogeologic processes. In this sense, the saturated quarries are broadly similar to natural ponds, wells, or sinkholes with respect to vulnerability. In addition, the planned land use and possible mineral rights at the quarries will be further investigated for the areas along the Proposed Project during detailed design.

One quarry was visited during the July 2023 field assessment and three quarries were viewed during the May 2024 field assessment. The July 2023 field view included the quarry directly east of Gardenia Avenue and the May 2024 field view included the quarries directly east and west of the Meagre Bay Pond and just west of Parker's Raceway. Observations were made around the perimeter of the quarries up to the northern most point of the quarry where it borders the CMW south the Proposed Project.

Overburden was observed in the quarry area (**Figure 11-15**). The quarry contained large excavators that were actively being used for excavation in the quarries (**Figure 11-16**). The NRA personnel also indicated that blasting was being utilised in the excavation process. Limestone is actively being excavated from the quarry for use in construction (**Figure 11-17**). The term "limestone" is used widely for rock that is quarried in the Cayman Islands, although technically the quarried rock is limestone or dolostone. The existing water depth was close to existing ground level (**Figure 11-18**).

Figure 11-15: Quarry Overburden (May 2024)

Figure 11-16: Quarried Rock (July 2023)

Figure 11-17: Active Quarry (July 2023)

Figure 11-18: Existing Water Level in Quarry (May 2024)

11.2.6 Desktop Studies

11.2.6.1 Lower Valley Freshwater Lens

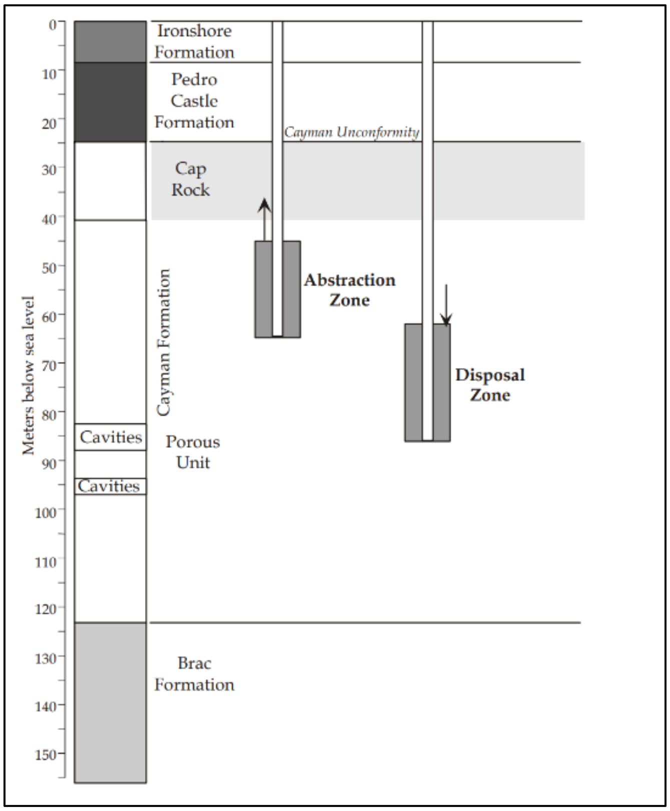
The Lower Valley Lens underlies numerous existing roads along with the area to be used for the Proposed Project, specifically the Will T area. The lens covers an area of 960 acres (388 ha) and is elongated in a generally east-west orientation (**Figure 11-13**). Cap rock in the upper part of the Cayman Formation acts as a barrier to upward movement of groundwater from the deeper part of the Cayman Formation. The Lower Valley Lens overlies northwest-trending photolineaments that represent bedrock fractures likely connected with the ocean. A lineament is a linear feature on the surface of the earth associated with geologic aspects such as discontinuities in bedrock. Lineaments may represent zones with relatively greater groundwater flow.

The freshwater table in the Lower Valley Lens is up to two ft (0.6 m) above sea level. The bottom of the freshwater lens is at 26 ft (8 m) below sea level. The transition zone between fresh and saline water extends from 26 ft (8 m) below sea level to 66 ft (20 m) below sea level. Saline water is present 66 ft (20 m) below sea level and lower.

The Lower Valley Lens has historically been a water supply source. Since 1998 the WAC has operated a reverse osmosis plant located over the Lower Valley freshwater lens (**Figure 11-13**). The WAC had previously operated the Lower Valley wellfield and reservoir from 1984 to 1994, pumping fresh groundwater at low abstraction rates. Currently the WAC pumps and treats only saline water (below the Lower Valley Freshwater Lens). This approach preserves the Lower Valley Lens for local water users.

The reverse osmosis plant disposes of brine in a zone deeper than the abstraction zone. At the Lower Valley reverse osmosis plant, the abstraction zone is approximately 150 to 220 ft (45-67 m) deep, the disposal zone is approximately 280 to 330 ft deep, and the distance between the abstraction well and the disposal well is approximately 330 ft (100 m) (**Figure 11-17**). Note that **Figure 11-19** indicates the brine disposal depth in 2001; however, in 2005 it was deepened to the depth stated in this report, because the production capacity of the reverse osmosis plant had increased. Disposal in the ocean is undesirable from an environmental standpoint.

Figure 11-19: Lower Valley Abstraction and Disposal Zones in Relation to Geological Succession



Source: Jones, B., van Genderen, H. J., & van Zanten, T. (2001)

11.2.6.2 North Side Freshwater Lens

The North Side Lens is north of the area to be used for the Proposed Project. The lens covers an area of 1,536 acres (622 ha) and is located south of Old Man Bay. The lens is centred on the topographic feature called "The Mountain", which refers to the area on Grand Cayman where the land surface elevation is the highest on the island. The fresh water exists in coarse white marl, gravel, and limestone. The North Side Lens overlies north- and northwest-trending bedrock lineaments.

The WAC does not have detailed water level data for the North Side Lens, but the expected water table elevation is 1.5 to 2 ft (0.5 to 0.6 m) above sea level. The bottom of the freshwater lens is 43 ft (13 m) below sea level, and seawater is present at 82 ft (25 m) below sea level. The WAC's North Side reverse osmosis plant (in the central part of Grand Cayman) is located outside the limits of the North Side Freshwater Lens (**Figure 11-13**).

11.2.6.3 Canal Impacts on Freshwater Lenses

Canalization for mosquito control in mangrove wetlands occurred on Grand Cayman beginning in the 1970s in order to drain water more quickly and reduce mosquito breeding. Canals in the 7-to-9-ft depth range (2 to 3 m) were cut through the shallow aquifer cap rock that serves as a confining bed. As a result, the breaching of the confining layer facilitated the hydraulic connection between freshwater lenses and the sea, and the water table was lowered closer to sea level in the freshwater lens discharge areas.

Three hydrogeologic studies performed for the CIG in the 1970s and 1980s concluded that canals had caused adverse impacts by reducing the thicknesses of the freshwater lenses. [Bermes, B. J. (1983); RDI (August 1975); RDI (November 1980)]. In addition, in a 1995 Technical Memorandum, the WAC determined that canals had adversely affected the lenses [Genderen, H.-J. van. (1995)]. Since that time, the development of canals has been discouraged and/or prohibited. In addition, some existing canals on Grand Cayman have been blocked under direction from the WAC.

Within the study area, the Proposed Project crosses the CMW in the vicinity of the Lower Valley Lens and the North Side Lens. In analysing the possible effects of the Proposed Project, the potential impacts of canalization need to be considered in relation to potential stormwater management approaches. For example, the application of utilising drainage swales in mangrove areas may have a similar impact as the existing canals have on the environment.

Figure 11-20: Blocked Canal (July 2023)

11.3 Project Impacts

This section describes the potential impacts to geo-environmental resources that are estimated to occur as a result of the Proposed Project, either directly or indirectly through construction or operations. The Proposed Project is described in **Chapter 6: Proposed Project – Engineering Features**. **Chapter 15: Summary of Direct, Indirect, Secondary/Induced and Cumulative Effects** includes Secondary, Induced, and Cumulative impacts.

For this specific discipline, the entire mainline corridor width of 220 ft (67 m) was used to calculate potential impacts along the mainline of the Proposed Project and a width of 41 ft (12.5 m) was used for the roadway sections that are included for the Will T Connector. The estimated Limits of Disturbance (LOD) areas surrounding the proposed intersections and access points, as well as locations with wider needs for cut or fill slopes were also included in the impact calculations.

11.3.1 Quantitative Impact Assessment

The following assessment involves evaluation of the potential impacts caused by the Proposed Project on the following resources:

- Freshwater Lenses and Brackish Groundwater
- Peat

Potential impacts from the Proposed Project on various resources may include a change in the quality of groundwater and aquifers and removal of peat. Since the potential change of groundwater quality impacts several locations, an overview is provided for this overall impact. Location-specific impacts are also provided as part of each section.

Groundwater and aquifer quality can be managed by avoiding or minimising contamination from construction efforts and from runoff during operations. Impacts to peat can be reduced by minimising disturbances during construction and avoiding or minimising pollution during operation.

11.3.1.1 Freshwater Lenses and Brackish Groundwater

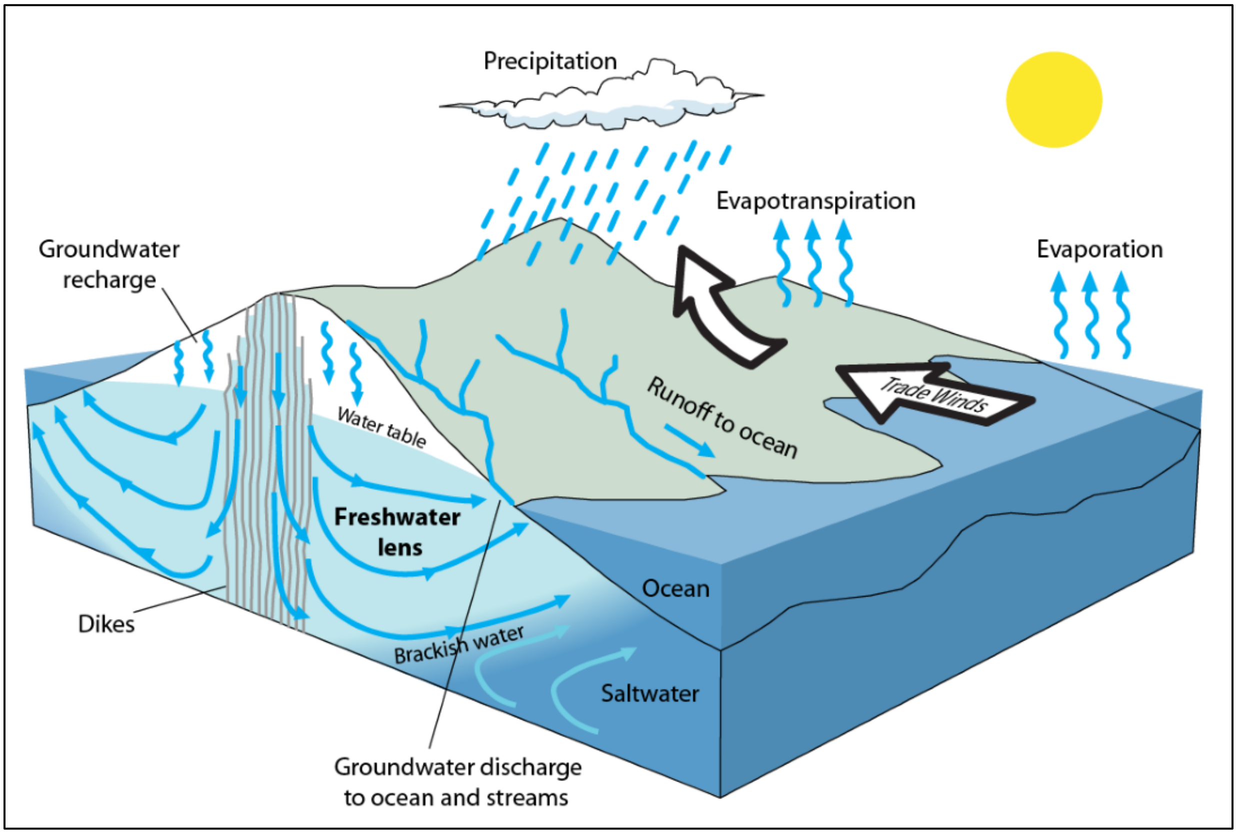
Freshwater lenses are critically important water supplies on Grand Cayman. Potential impacts to freshwater lenses include the addition of impermeable surfaces that could diminish groundwater recharge or redirect stormwater away from the freshwater lenses. The term “groundwater” in the context of this assessment refers to underground water throughout the whole project study area, which is mostly brackish (not fresh) water with a chloride concentration ranging from 600 to 19,000 mg/l. Certain changes in recharge could 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. Changes in groundwater quality could theoretically follow mixing of the existing groundwater with stormwater infiltrating from runoff from the Proposed Project. Changes in the unconfined aquifer water level could result in a rise in the water table where stormwater is newly infiltrated, or the water table could drop locally if infiltration were reduced due to adding new impermeable surfaces. **Figure 11-21** illustrates the factors which affect groundwater recharge within oceanic islands (similar to Grand Cayman).

The freshwater lenses can also deteriorate as potential sources of potable supply if the groundwater flow system supporting the lens undergoes changes that diminish the volume of freshwater. This may result in eventual salt-water contamination of all but the shallowest wells used to extract fresh groundwater.

In the Lower Valley and North Side areas, the freshwater lens is primarily used for residential use, agriculture, and horticulture, where farming takes place, and residences have fruit trees and other crops that can be grown because there is fresh groundwater. The fresh groundwater also supports the presence of specific naturally occurring vegetation that could be impacted by changes in the presence of fresh groundwater.

The WAC operates a reverse osmosis plant at the Lower Valley Water Works, and this plant abstracts saline groundwater from below the shallow fresh groundwater. The saline brine from the plant is disposed below the abstraction zone. The fresh water produced at Lower Valley Water Works is distributed via the public water supply system.

Figure 11-21: Conceptualization of the Factors that Affect Groundwater Recharge in Oceanic Islands



Source: U.S. Geological Survey by Oregan Water Science Centre, March 2022

The construction of the Proposed Project may involve deep foundations such as piers, columns, or piles. The specific types, sizes and locations of necessary bridge and other roadway structure foundations will be assessed during the detailed design phase of the project. Drilling for deep foundations can also potentially increase hydraulic connections between layers containing groundwaters of different quality (e.g., fresh or saline) thus leading to contamination.

The use of disposal wells adjacent to roadways is a current practice for the disposal of stormwater in Grand Cayman, and they may also be implemented as part of the Proposed Project. Depths and locations of existing stormwater disposal wells were provided by the NRA on August 4, 2023. The provided well data indicates that the stormwater is typically drained into the subsurface at levels that are stratigraphically underneath freshwater lenses, to minimise mixing of the stormwater with fresh groundwater. The stormwater disposal wells are generally deeper than the lower limits of freshwater lenses at Grand Cayman, based on stormwater disposal well data provided by the WAC. Therefore, the water in the stormwater disposal wells is typically entering the unconfined aquifer where the aquifer is brackish.

Stormwater drainage patterns and recharge rates may be impacted if the project requires construction of stormwater disposal wells or other means for the conveyance or discharge of stormwater. Changes in groundwater quality could theoretically follow mixing of the existing groundwater with stormwater infiltrating off new roadway. Changes in the unconfined aquifer water level could be a rise in the water table where stormwater is newly infiltrated, or the water table could drop locally if infiltration were reduced due to new impermeable surfaces.

The potential release of contaminants may also impact groundwater, including the freshwater lenses. 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 Project have the potential to migrate into the underlying aquifers leading to deterioration in groundwater quality. The amount of possible impact from the Proposed Project is directly related to the facility location in either a lens recharge or discharge area. The lens recharge areas are depicted in **Figure 11-13**. The lens discharge areas begin at the limits of the recharge area and are not delineated.

Theoretically, a circular freshwater lens is recharged in its centre (where it is thickest) by precipitation, and the lens discharges fresh groundwater at the edges of the hypothetical circle. The lenses on Grand Cayman have non-circular shapes, primarily due to the configuration of the underlying geology. The CIG 2D mapped areas of the freshwater lenses (on the hydrogeologic map **Figure 11-13**) show the lens recharge areas. The lens discharge areas are the areas outside the lenses, including wetlands. Specifically, the discharge areas include the wetlands generally located north of the Lower Valley lens, and southeast of the North Side lens.

Construction of the Proposed Project within the lens recharge areas could result in direct impacts on the lenses. In addition, if the discharge areas are disrupted, the lenses may have their configurations and discharge flow directions changed. Generally, groundwater moves from areas of higher groundwater elevation to areas of lower groundwater elevation. In this sense the edges of the freshwater lenses on the hydrogeologic map (**Figure 11-13**) are the edges of discharge areas. Based on WAC data, the freshwater lens recharge areas are the zones within the 600-mg/l chloride contours. At increasing distance away from the freshwater lens boundaries, the role of the swampy area as mainly a receiving zone for migrating freshwater will tend to diminish. For example, areas closer to the Caribbean Sea will tend to be zones of mixing with seawater. In terms of potential impact, impacts within the lens recharge area are considered more critical than impacts within the lens discharge area.

Furthermore, soil compaction and the increased impervious surfaces (pavement) from the Proposed Project may result in reduced infiltration, which may impact the recharge rate and water level in the Lower Valley and North Side freshwater lenses, as well as groundwater.

During the construction of the Proposed Project, temporary dewatering works for foundation construction may result in a localised and potential temporary decline in groundwater levels along with the potential deterioration in groundwater quality via induced saline intrusion.

These potential impacts of the Proposed Project have been assessed individually for the Lower Valley Freshwater Lens, the North Side Freshwater Lens, and brackish groundwater. The impact of the project on the change of drainage patterns and the potable supply of the freshwater lenses have been assessed by the distance from the Proposed Project to the freshwater lenses recharge area, as these are the only identified delineated boundaries. Reduced infiltration capacity of the freshwater lenses and groundwater has been assessed by measuring the increase of impervious surface area and assuming that no sustainable drainage solutions would be employed. The temporary dewatering impact of the project was assessed along the entire length of the Proposed Project through the CMW. See **Table 11-2** for the quantified values for distance from the freshwater lenses, the amount of impervious surface area, and the length of roadway through the CMW.

11.3.1.2 Peat

Peat may potentially be removed, covered over, compacted, or contaminated during construction of the Proposed Project, any of which may impact the CMW. The peat provides a substrate for the new growth for many species of flora, including but not limited to mangrove species. Peat is a component of a healthy wetland ecosystem and sequesters and purifies toxins from the surrounding groundwater. The removal of peat and potential for the release of GHGs is described further in **Chapter 10: Greenhouse Gas Emissions**. The impact to peat was assessed by the overall quantity of peat removal anticipated for the Proposed Project.

The total quantity of peat removal for the Proposed Project is based on the trial pit data supplied by NRA for the originally gazetted corridor from 2008 and 2014 described in **Section 11.2.3: Peat**. The data included depths and locations of peat, which were utilised to establish a conceptual level profile for the peat areas which were used to calculate the volume of potential excavation along the width and length of the Proposed Project corridor.

The original trial pits were primarily located along the original gazetted corridor and this information was projected to the area of the Proposed Project. Any missing pieces of data between trial pit locations were interpolated based on adjacent data and available aerial imagery.

The quantity of potential peat removal for the Proposed Project took into account the anticipated corridor length and width, and potential locations and depths of peat based on provided information described in **Section 11.2.2: Soils**. Additional information regarding peat quantities is provided within the **Chapter 6: Proposed Project – Engineering Features**. See **Table 11-2** for the quantified values of volume of peat removal for the Proposed Project and the length of roadway through the CMW.

Table 11-2: Summary of Geo-Environmental Quantitative Impact Assessment

Resource	Potential Impact	Assessment Method	Proposed Project
Lower Valley Lens *(total recharge area = 960 acres/ 388 ha)*	Impact on lens recharge area	Acreage of roadway construction within the mapped recharge area	10.3 ac** 4.2 ha
North Side Lens	Impact on lens recharge area	Distance of additional roadway from the mapped recharge area	0.6 mi; 0.9 km
Brackish Groundwater	Contamination of groundwater due to contaminant spills and infiltration of road runoff	Increase of impervious surface area*	145 ac; 59 ha
Peat	Peat impact on CMW	Additional length of roadway through CMW	2.8 mi; 4.5 km
		Total volume of peat removal; *cubic yards (yd^3); cubic metres (m^3)*	441,579 yd^3; 337,612 m^3

* Includes asphalt pavement area (for travel lanes, shoulders, micromobility path) and concrete pavement area (for sidewalks, bus stops, traffic separators and median barrier)

**Estimated 1% of total recharge area

See **Chapter 6: Proposed Project – Engineering Features** for additional details.

11.3.2 Qualitative Assessment of Potential Impacts

A qualitative impact assessment was performed for the Baseline Condition and for the Proposed Project to identify the significance of the potential effects. The assessment included three steps, including (1) rating the importance of water environment features, (2) determining the magnitude of impact, and (3) identifying the overall assessment score. Methodology is described in **Section 11.1.5: Qualitative Assessment Methodology** and **Appendix E - Shortlist Evaluation: Attachment E – Geo-Environmental – Assessment of Alternatives**. The results of the assessment are described as follows.

11.3.2.1 Importance of Water Environment Features

The first step in the qualitative assessment was rating the importance of each water features/resources and peat. Potential ratings included low, medium, high and very high.

Lower Valley Freshwater Lens: As described in **Section 11.2.6.1: Lower Valley Freshwater Lens**, the Lower Valley Freshwater Lens is an existing water supply source for potable water for a localized population. Fresh groundwater also supports agriculture and horticulture, including farming and residences with fruit trees and other crops, and the presence of specific naturally occurring vegetation.

While there is also a population that obtains treated public water from the WAC's desalination plant, there are domestic well owners that directly rely on the freshwater lens as a supply of water. While connection to the existing public water system is possible as a substitution, consumers who previously used private wells might have a new cost if they needed to switch to desalinated, public water for their supply. The Lower Valley Freshwater Lens receives a **"Very High"** rating on the Importance of Water Environment Features scale due to the high freshwater quality, its localized use as a fresh water supply, and limited potential for substitution.

North Side Freshwater Lens: As described in **Section 11.2.6.2: North Side Freshwater Lens**, the North Side Freshwater Lens is an existing water supply source for potable water for a localized population. Fresh groundwater also supports agriculture and horticulture, including farming and residences with fruit trees and other crops, and the presence of specific naturally occurring vegetation. The Proposed Project is approximately 0.6 mi (0.9 km) from the North Side Freshwater Lens recharge area.

While there is also a population that obtains treated public water from the WAC's desalination plant, there are domestic well owners that directly rely on the freshwater lens as a supply of water. Consumers previously using only private wells would have a new cost if they needed to connect to public water, including situations where it was to be used for agriculture or horticulture.

The North Side Freshwater Lens receives a **"Very High"** rating on the Importance of Water Environment Features scale due to the high freshwater quality, its localized use as a fresh water supply, and limited potential for substitution.

Brackish Groundwater: Brackish groundwater refers to the subsurface water located beneath the EIA study area, which is mostly brackish (a mixture of salt water and fresh water). Brackish water is widely available though is unusable without treatment. Due to its generally non-potable water quality and wide availability, the brackish groundwater receives a **"Medium"** rating on the Importance of Water Environment Features scale.

Peat: The peat provides the substrate for new growth for many species of flora, is a component of a healthy wetland ecosystem, and sequesters and purifies toxins from the surrounding groundwater. Due to the direct connection of peat with ecosystems of high national priority with limited potential for substitution (CMW), peat receives a **"Very High"** rating on the Importance of Water Environment Features scale.

11.3.2.2 Magnitude of Impact

The second step in the qualitative assessment was to determine the magnitude of impact of the Proposed Project on the water features/resources and peat. Potential ratings included Negative, Negligible, and Positive. Negative and Positive impacts were further categorized as Major, Moderate, and Minor.

Lower Valley Freshwater Lens: A portion of the Proposed Project extends across the recharge area of the Lower Valley Freshwater Lens and partially crosses the discharge area. The Proposed Project is anticipated to result in 10.3 ac (4.2 ha) of construction disturbance within the Lower Valley Freshwater Lens recharge area. This equates to approximately 1% of the identified overall recharge area. Potential impacts from construction within the recharge area include reduced infiltration and direct contamination during construction. Due to the potential for reduced infiltration and contamination, the Proposed Project is anticipated to have a negative impact on the Lower Valley Freshwater Lens. However, based upon the low area of impact (1% of recharge area) and amount of existing development within the Lower Valley Freshwater Lens recharge area, the Proposed Project is anticipated to have an insignificant impact on the overall waterbody quality. No long-term channelization is anticipated. In addition, the groundwater mounding analysis indicted that the stormwater modelling runoff from the Proposed Project may have a minimal impact on the upper surface of the Lower Valley Freshwater Lens (see **Section 12.3.6 Groundwater Mounding Analysis**). Therefore, it receives a "**Minor Negative**" rating on the Magnitude of Impact scale.

North Side Freshwater Lens: The Proposed Project is located approximately 0.6 mi (0.9 km) south of the identified North Side Freshwater Lens recharge area. Due to the distance, the Proposed Project is located within the North Side Freshwater Lens discharge area. No long-term channelization is anticipated. In addition, the groundwater mounding analysis indicted that the stormwater modelling runoff from the Proposed Project may have a minimal impact on the upper surface of the North Side Freshwater Lens (see **Section 12.3.6 Groundwater Mounding Analysis**). Therefore, the Proposed Project is anticipated to have an immeasurable impact on the North Side Freshwater Lens. Therefore, it receives a **"Negligible"** rating on the Magnitude of Impact scale.

Brackish Groundwater: The Proposed Project extends across area underlain by brackish groundwater. While the brackish groundwater is mostly non-potable, it is ultimately hydrologically connected with freshwater. Potential impacts include decrease in infiltration due to additional impervious surface area and disruption to natural flow patterns beneath the roadway fill materials. The Proposed Project may result in an estimated 145 ac (59 ha) increase in impervious area. Although the Proposed Project is anticipated to have a negative impact to the adjacent groundwater, it is anticipated to be limited in size/proportion due to the abundance of brackish groundwater throughout the EIA study area. Therefore, it receives a **"Minor Negative"** rating on the Magnitude of Impact scale.

Peat: The Proposed Project is anticipated to require approximately 441,579 yd^3 (337,612 m3) of peat removal for construction. The Proposed Project is also anticipated to result in the construction of approximately 2.8 mi (4.5 km) of new roadway within the CMW. Due to the volume of peat removal required and dependence of the CMW system on peat for both substrate and water quality, peat removal is anticipated to have a negative, measurable impact on the CMW system; however, based on the overall size of the CMW system (Figure 11-13), the Proposed Project is not anticipated to result in a degraded quality to the overall CMW system due to peat removal. Therefore, it receives a "Moderate Negative" rating on the Magnitude of Impact scale.

11.3.2.3 Overall Assessment Score

The overall assessment score was developed by combining the ratings for the importance of water features and peat with the anticipated magnitude of impact into an Overall Qualitative Rating for the Proposed Project. A summary of the anticipated magnitude of impact for the Proposed Project, along with the importance of each identified feature, is shown in **Table 11-3** and the overall assessment score is shown in **Table 11-4**.

The Proposed Project is anticipated to have a large adverse impact on one feature (peat) with moderate or slight impacts on the other identified features; as a result, the overall qualitative assessment is a "Large Adverse" rating.

Table 11-3: Summary Table of Importance and Magnitude of Impact by Resource

Resource	Importance	Anticipated Magnitude of Impact from Proposed Project
Lower Valley Freshwater Lens	Very High	Minor Negative
North Side Freshwater Lens	Very High	Negligible
Brackish Groundwater	Medium	Minor Negative
Peat	Very High	Moderate Negative

Table 11-4: Summary Table of Qualitative Impacts on Geo-Environmental Resources

Resource	Proposed Project
Lower Valley Freshwater Lens	Moderate Adverse
North Side Freshwater Lens	Slight Adverse
Brackish Groundwater	Neutral
Peat	Large Adverse
Overall Qualitative Rating	**Large Adverse**

11.3.3 Potential Construction and Operation Impacts

Potential impacts during the construction and operation phases of the Proposed Project were assessed by various attributes/variables to determine the magnitude of impact, importance/sensitivity of the resource, and impact significance. Potential construction phase impacts are included in **Table 11-5** and potential operation phase impacts are included in **Table 11-6.**

11.3.3.1 Construction Phase

Potential construction phase impacts were assessed and may include the following:

- Freshwater lens pollution
- Freshwater lens recharge disruptions
- Freshwater lens drainage into Karst formations
- Peat compaction, removal, and pollution
- Hydrogen sulphide release

Construction activities may cause negative changes to aquifer, freshwater lens, and groundwater quality. The equipment used and activities performed on-site may release contaminants that pollute peat and underlying aquifers. Temporary storage, stockpiling of materials and construction phases may also compact or cover peat. Peat disturbance may also release hydrogen sulphide, which poses health hazards to workers in the area.

These potential impacts were evaluated and were estimated to have a low to high likelihood of occurrence with a medium to high certainty. They were also estimated to be adverse, local, and short term, except for freshwater lens impacts, which may be long term and regional. These potential impacts were also estimated to range from low to high in magnitude, high in sensitivity, and slight adverse to large adverse in significance. The potential construction phase impacts are described in **Table 11-5**.

Table 11-5: Construction Phase Impacts on Geo-Environmental Resources

Receptor / Resource / Impact Summary	**Description / Potential Effect (*include likelihood and certainty)***	**Type / Temporal / Geographic**	**Magnitude**	**Sensitivity (Importance)**	**Significance**
Freshwater Lenses /Pollution	Lenses may be polluted by construction activities, including dewatering. This effect has a medium likelihood of occurrence and has been identified with a medium certainty.	Adverse Long-Term Regional	Major Negative	High	Large Adverse

Receptor / Resource / Impact Summary	**Description / Potential Effect (*include likelihood and certainty)***	**Type / Temporal / Geographic**	**Magnitude**	**Sensitivity (Importance)**	**Significance**
Freshwater Lenses /Recharge - Hydrogeological changes	Lenses might have their shapes, configurations, and discharge flow directions changed. Loss of recharge and regional head changes may occur. This effect has a medium likelihood of occurrence and has been identified with a medium certainty.	Adverse Long-Term Regional	Medium Negative	High	Moderate Adverse
Freshwater Lenses / Karst formation	Lenses may inadvertently drain into underlying Karst formations. This effect has a low likelihood of occurrence and has been identified with a medium certainty.	Adverse Long-Term Regional	Major Negative	High	Large Adverse
Peat	Peat may potentially be compacted by construction activities and equipment. This effect has a high likelihood of occurrence and has been identified with a high certainty.	Adverse Short-Term Local	Minor Negative	High	Slight Adverse
Peat	Peat may be removed and/or covered by construction activities and equipment. This effect has a high likelihood of occurrence and has been identified with a high certainty.	Adverse Short-Term Local	Minor Negative	High	Slight Adverse

Receptor / Resource / Impact Summary	**Description / Potential Effect (*include likelihood and certainty)***	**Type / Temporal / Geographic**	**Magnitude**	**Sensitivity (Importance)**	**Significance**
Peat	Peat may be polluted by construction activities and equipment. This effect has a medium likelihood of occurrence and has been identified with a medium certainty.	Adverse Short-Term to Long-Term Local	Minor Negative	High	Slight Adverse
Release of Hydrogen Sulphide from peat disturbance	Release of Hydrogen Sulphide during peat disturbance, risking health issues. This effect has a high likelihood of occurrence and has been identified with a medium certainty.	Adverse Short-term Local	Minor Negative	High	Slight Adverse

11.3.3.2 Operation Phase

Potential operation phase impacts were assessed and may include the following:

- Freshwater lens pollution
- Freshwater lens recharge disruptions
- Freshwater lens flow pattern changes
- Peat pollution

These potential impacts were evaluated and were estimated to have a low to high likelihood of occurrence with a medium to high certainty. They were also estimated to be adverse, long-term, and regional except for the drop in the groundwater level, which is local. These potential impacts were also estimated to range from low to high in magnitude, medium to high in sensitivity, and slight adverse to large adverse in significance. The potential operation phase impacts are described in **Table 11-6**.

Table 11-6: Operation Phase Impacts on Geo-Environmental Resources

Receptor / Resource / Impact Summary	Description / Potential Effect *(include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude	Sensitivity (Importance)	Significance
Freshwater Lenses /Pollution	Lenses and groundwater may be polluted and contaminated due to spills and infiltration of road runoff. This effect has a medium likelihood of occurrence and has been identified with a high certainty.	Adverse Long-Term Regional	Major Negative	High	Large Adverse
Freshwater Lenses /Recharge – Hydrogeological changes	Lenses may experience disrupted hydrological regimes and reduced groundwater recharge and flow; changed groundwater flow patterns. This effect has a medium likelihood of occurrence and has been identified with a medium certainty.	Adverse Long-Term Regional	Intermediate Negative	High	Large Adverse

Receptor / Resource / Impact Summary	**Description / Potential Effect** *(include likelihood and certainty)*	**Type / Temporal / Geographic**	**Magnitude**	**Sensitivity (Importance)**	**Significance**
Freshwater Lenses / Flow pattern changes	Lenses may experience a local drop in the water table if infiltration were reduced by new impermeable surfaces. This effect has a high likelihood of occurrence and has been identified with a medium certainty.	Adverse Long-Term Local	Minor Negative	Medium	Slight Adverse
Peat	Peat adjacent to the road may be contaminated during maintenance. This effect has a low likelihood of occurrence and has been identified with a medium certainty.	Adverse Long-Term Regional	Minor Negative	High	Slight Adverse

11.4 Mitigation Measure Considerations

The following sections describe potential mitigation considerations to mitigate the impacts described for the identified geo-environmental resources. **Table 11-7** describes the characterisations used to evaluate the impacts after mitigation considerations have been applied.

Table 11-7: Impact Analysis Factors

Characterisation	Description	Quantitative Measure or Definition of Qualitative Categories
Magnitude	The size or degree of the effects compared against baseline conditions or reference levels, and other applicable measurement parameters (i.e., standards, guidelines, objectives)	**Negligible (N) |** Differing from the average baseline conditions to a very small degree, but within the range of the natural variation **Very Low (VL) |** Differing from the average baseline conditions to a small degree, but very minimally out of the range of the natural variation **Low (L) |** Differing from the average baseline and outside the range of natural variation but less than or equal to appropriate guideline or threshold value **Medium (M) |** Differing from the average baseline and outside the range of natural variation and marginally exceeding a guideline or threshold value **High (H) |** Differing from the average baseline and outside the range of natural variation and exceeding a guideline or threshold value
Geographic Extent	The geographic area over which the effects are likely to be measurable	**Limits of Disturbance (LOD) |** Occurs within the Proposed Project LOD **Outside Limits of Disturbance (OLOD) |** Occurs outside of the Proposed Project LOD, but within the identified Study Area
Timing	Considers when the environmental effect is expected to occur. Timing considerations are noted in the evaluation of the environmental effect, where applicable or relevant.	**Not Applicable (NA) |** Seasonal variations are not likely to change the effect **Applicable (A) |** Seasonal aspects may affect the outcome of the effect
Duration	The time period over which the effects are likely to last	**Short-Term (ST) |** The effect is reversible at the end of construction works **Medium-Term (MT) |** The effect is reversible within a defined length of time **Long-Term (LT) |** The effect is reversible over an extended length of time
Frequency	The rate of recurrence of the effects (or conditions causing the effect)	**Once (O) |** Effects occur once **Occasional (Oc) |** Effects that could occur randomly throughout the project lifetime **Regular (R) |** Effects can occur at regular intervals through construction and/or operation **Continuous (C) |** Effects are continuous throughout construction and operation

Characterisation	Description	Quantitative Measure or Definition of Qualitative Categories
Reversibility	The degree to which the effects can or will be reversed (typically measured by the time it will take to restore the environmental attribute or feature)	**Reversible (R) |** The baseline conditions will recover to their standard after the construction works are completed **Partially Reversible (PR) |** Mitigation can return the baseline conditions **Not Reversible (NR) |** Mitigation cannot guarantee a return to baseline conditions

11.4.1 Construction Phase

During construction, a number of measures can be taken to potentially prevent and reduce impacts on and off-site. The following section describes potential mitigation considerations to address the impacts to the identified geo-environmental resources. **Table 11-8** describes each potential impact, the effects, the mitigation considerations, and the overall significance.

In order to fully develop and defined mitigation measures, additional survey, field investigation, detailed design and geotechnical data is required to determine drainage patterns, develop staging/stockpile locations, determine/design temporary construction access/drainage plans and (where feasible) integrate with the existing and proposed drainage systems.

Freshwater Lenses: The release of contaminants during construction is also a potential impact on freshwater lenses. 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 Project have potential to migrate into the underlying aquifers leading to deterioration in groundwater quality. A series of best practice pollution prevention techniques are suggested for consideration during construction. In addition, it is suggested that the placing of staging and stockpile areas on or near freshwater lenses should be avoided.

Brackish water intrusion into freshwater lenses may occur in various ways related to construction. Intrusion from temporary construction dewatering is possible and dewatering should be limited to what is essential for construction. During dewatering, water levels and salinity in the unconfined aquifer should be monitored. Intrusion from undesirable mixing of shallow and deep groundwater is also possible and could occur with new stormwater inputs to the aquifer. If stormwater wells are drilled into the freshwater lens, they could potentially be grouted similar to effluent disposal wells per WAC requirements. Another cause of degradation of the lenses is non-point source contamination. Development of spill response plans and chemical/waste hauler regulations can minimise potential impacts. In addition, monitoring of water quality at abstraction points can be used as a control measure during construction works.

Temporary dewatering during the construction phase for the excavation for the proposed roadway foundations may result in localised and temporary decline in groundwater levels, along with deterioration in groundwater quality via induced saline intrusion. This construction may involve deep foundations such as piers, columns, or piles. Drilling for deep foundations can also potentially increase hydraulic connections between layers containing groundwaters of different quality (e.g., fresh or saline) thus leading to contamination. During the construction of the Proposed Project, temporary dewatering of foundations may result in localised and temporary decline in groundwater levels and deterioration in groundwater quality via induced saline intrusion.

The construction of the Proposed Project may also require areas of soil compaction that may result in reduced infiltration, which may impact the recharge rate and water level in the freshwater lenses. The use of low-impact construction vehicles and/or mats and not placing staging and stockpile areas on or near freshwater lenses may minimise this impact.

Regional head changes may also be caused as a result of construction. The Proposed Project should consider this possibility during the detailed design phase and carefully design in portions of the flow system supporting the lenses.

Inadvertent draining of the lenses into underlying Karst formations has been identified as a possible impact that may occur during the construction of the Proposed Project. Instituting a comprehensive subsurface (i.e., drilling) program to determine the underlying stratigraphy is necessary to fully understand this possible impact.

Peat: Peat may potentially be compacted during construction. The use of low-impact construction vehicles and/or mats and not placing staging and stockpile areas on peat may minimise this impact. Removal or cover over of peat is an additional possible impact, which can be reduced by salvaging and reusing peat to the greatest extent possible. Additionally, using the Proposed Project's corridor for haul road placement may also reduce the impact on areas of peat.

Release of Hydrogen Sulphide from Peat Disturbance: Hydrogen sulphide poses a health hazard to workers during peat disturbance. To minimise health risks, portable hydrogen sulphide detectors and personal protection equipment, such as tight safety goggles and gas masks, are recommended when working in poorly ventilated conditions where there is potential for hydrogen sulphide release. This chemical compound is related to a specific health and safety issue particular to the unique and extensive mangrove deposits on Grand Cayman.

Table 11-8: Construction Phase Mitigation for Geo-Environmental Resources

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental – Freshwater Lenses	Release of contaminants causing deterioration in groundwater quality.	Develop best practice pollution prevention techniques. Avoid placing staging and stockpile areas on or near freshwater lenses. Monitor and control water quality	L	OLOD	A	MT	Oc	NR	Potential freshwater lens pollution	Not Significant - mitigation measures would limit groundwater contamination effects.
			A Low magnitude of impact is anticipated. Due to the karst geology and lack of shallow low permeability confining zones, contaminants may migrate into aquifers. Impacts may occur Outside the LOD if pollutants spread through ground and surface water. Timing is Applicable; precipitation increases from June – October, contributing to variations in the flow system throughout the year and influencing the impact. The duration will be Medium-Term, ending when construction finishes. The frequency will be Occasional. The impact is Not Reversible as a return to baseline conditions cannot be guaranteed.							

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental – Freshwater Lenses	Dewatering for excavation for foundations may cause decline in groundwater levels and quality.	Develop best practice pollution prevention techniques. Instrumentation monitoring and control during the construction.	H	LOD/ OLOD	NA	LT	R	NR	Potential groundwater pollution and quality loss.	Significant- though mitigations can minimise the impact, a return to baseline conditions cannot be guaranteed.
			A High impact is anticipated due to the disruption that would occur to local aquifers. Impacts will be present within and Outside the LOD. Timing is Not Applicable. Seasonal variations are unlikely to influence the impact. The impact will have a Long-Term duration as effects will last after construction finishes. The frequency will be Regular. Impacts will be present as dewatering occurs. The impact is Not Reversible. Mitigation efforts are unlikely to restore baseline conditions.								

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental – Freshwater Lenses	Construction may require drilling for deep foundations, which could cause contamination between layers of groundwater.	Grout drilled holes in accordance with regulations. Instrumentation monitoring and control during the construction.	H	LOD/ OLOD	NA	LT	R	NR	Potential groundwater pollution and quality loss.	Significant- though mitigations can minimise the impact, a return to baseline conditions cannot be guaranteed.
			A High impact is anticipated due to the disruption that would occur to local aquifers. Impacts will be present within and Outside the LOD. Timing is Not Applicable. Seasonal variations are unlikely to influence the impact. The impact will have a Long-Term duration as effects will last after construction finishes. The frequency will be Regular. Impacts will be present as drilling occurs. The impact is Not Reversible. Mitigation efforts are unlikely to restore baseline conditions.								

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental – Freshwater Lenses	Soil compaction may cause reduced infiltration, which may impact recharge rate and water level in freshwater lenses.	Avoid placing staging and stockpile areas on or near freshwater lenses. Use of low-impact construction vehicles and/or mats.	L	LOD	A	MT	R	PR	Reduced freshwater lens recharge	Not Significant- mitigation measures would limit soil compaction.
			Assuming mitigation measures are applied, there would a Low magnitude of impact to the site. Only soil on-Site would be compacted; impacts would be limited to the LOD. Timing is Applicable; compaction may worsen from June – October due to the seasonal increase in precipitation. Soil will be wetter and more easily compressed. The impact will have a Medium-Term duration, lasting until construction concludes. The frequency will be Regular until construction is complete. The impact is Partially Reversible- mitigation efforts will minimise impacts.							

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental – Freshwater Lenses	Regional head changes	Careful designing of the Proposed Project in portions of the flow system supporting the lenses	L	LOD/ OLOD	A	LT	R	NR	Regional head changes.	Not Significant- mitigation measures would minimise regional head changes.
			Assuming mitigation measures are applied, there would be a Low magnitude of impact. Areas within and Outside the LOD may be impacted. Timing is Applicable. Precipitation increases from June – October, contributing to variations in the flow system throughout the year and influencing the impact. The duration will be Long-Term, ending when construction finishes. The frequency would be Regular; changes will occur as construction continues to change the landscape. The impact is Not Reversible. A return to baseline conditions could not be guaranteed.							

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental – Freshwater Lenses	Inadvertent draining of the lenses into underlying Karst formations	Comprehensive subsurface (i.e., drilling) geotechnical investigations to determine the underlying stratigraphy.	VL	LOD/ OLOD	NA	LT	Oc	NR	Risk of freshwater lenses draining into Karst formations.	Not Significant- mitigation measures would determine underlying stratigraphy and prevent draining of the lenses
			A Very Low impact is anticipated. Determining the underlying stratigraphy will prevent construction from causing drainage from lenses into underlying Karst formations. Areas within and Outside the LOD may be impacted. Timing is Not Applicable. Seasonal changes are unlikely to influence the impact. The duration will be Long-Term, lasting as long as construction does. The impact would have an Occasional frequency. The impact is Not Reversible. A return to baseline conditions could not be guaranteed.								

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental – Peat	Peat may potentially be compacted during construction.	Avoid placing staging and stockpile areas and access on peat. Use low-impact construction vehicles and/or mats.	M	LOD	NA	LT	R	PR	Compaction of peat on-site.	Not Significant-mitigation measures would limit peat compaction.
			A Medium magnitude of impact is anticipated. Only peat within the LOD will be compacted during construction. Timing is Not Applicable. Seasonal variations seem unlikely to influence the impact. The impact will be Long-Term, ending when construction does. The frequency will be Regular as construction activities will move and store equipment on-Site at set intervals. The impact is Partially Reversible. Mitigations are not guaranteed to restore baseline conditions.								

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental – Peat	Peat may be removed or covered over.	Salvage and reuse mangrove peat to the greatest extent possible. See **Chapter 10: Greenhouse Gas Emissions** for additional details regarding peat mitigation measure considerations.	M	LOD	NA	LT	R	NR	Excessive discard of mangrove peat.	Not Significant- mitigation measures would limit removal and cover over of peat. See **Chapter 10: Greenhouse Gas Emissions** for additional details regarding peat mitigation measure considerations.
			A Medium magnitude of impact is anticipated. Only peat within the LOD will be removed or covered. Timing is Not Applicable. Seasonal changes are unlikely to influence the impact. The impact will have a Long-Term duration since the peat removal will be permanent. The frequency will likely be Regular, occurring as construction progresses. The impact is Not Reversible. A return to baseline conditions cannot be guaranteed.								

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental - Peat	Peat may potentially be contaminated during construction.	Avoid placing staging and stockpile areas and access on peat. Develop best practice pollution prevention techniques.	L	LOD	NA	MT	R	PR	Risk of peat pollution.	Not Significant- mitigation measures would limit peat contamination.
			A Low magnitude of impact is anticipated. Impacts would only occur within the LOD. Seasonal changes are unlikely to influence the impact. The duration will be Medium-Term, ending when construction finishes. The frequency will be Regular. Materials will be moved around the Site as needed. The impact is likely Partially Reversible.							

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental – Hydrogen Sulphide	Release of hydrogen sulphide during activities disturbing peat.	Recommend portable hydrogen sulphide detectors and personal protection equipment during peat disturbance.	L	LOD	NA	ST	R	R	Health hazards to workers.	Not significant- mitigations will prevent ill effects and conditions will return to baseline once construction ends.
			A Low magnitude of impact is anticipated. Impacts will be present only within the LOD. Timing is Not Applicable. Seasonal variations are unlikely to influence the impact. The duration is Short-Term. The impact will only last as long as peat disturbance does. The frequency will be Regular- whenever construction disturbs peat. The impact is likely Reversible. The area will return to baseline conditions when peat disturbance ends.							

11.4.2 Operation Phase

During roadway operation (post-construction), a number of measures can be implemented to potentially prevent and reduce impacts on and off-site. The following section describes the potential mitigation considerations that could be used to address the impacts to the geo-environmental resources. **Table 11-9** describes the impacts and mitigation considerations during the operations phase.

Aquifer Quality: Tidal flooding, surface water flooding, and extreme weather/climate change-induced flood events may impact aquifer quality. Protocols for potentially contaminative on-site activities should be included in a Site Environment Management Plan (EMP). The preparation of a comprehensive waste management plan should be considered describing appropriate waste management for emergency situations, factoring in emergency response and flooding.

Freshwater Lenses: There is potential for release of contaminants 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 Project have potential to migrate into the underlying aquifers, leading to deterioration in groundwater quality. Certain changes in recharge could negatively influence hydraulic conditions in and around freshwater lenses or degrade the quality of recharging water. Changes in groundwater quality could theoretically follow mixing of the existing groundwater with stormwater infiltrating from the Proposed Project. Mitigation considerations should maintain good water quality in discharged water and can include best practice pollution prevention techniques to minimise release of contaminants during operation and to ensure that discharges from the site to ground and surface water meet applicable water quality discharge criteria.

Contamination of groundwater is possible due to contaminant spills and infiltration of road runoff. Protocols for potentially contaminative on-site activities can be included in the Site EMP and a waste management plan can be prepared.

Stormwater management options should be identified during detailed design to avoid or minimise impacts on the freshwater lenses and ensure that hydrological regimes are maintained, and aquifers are recharged as with baseline conditions. Stormwater systems should be designed to be effective with rising sea level both from surface and ground water, i.e., pump stations rather than gravity-based systems. Elevated structures, such as bridges, should be used in highly vulnerable areas.

The increased impervious surface (pavement) area and soil compaction may contribute to reduced infiltration and redirect stormwater away from the freshwater lenses, which could reduce the groundwater recharge rate in the Lower Valley and North Side freshwater lenses, as well as groundwater. Changes in drainage patterns also have the potential to impact the recharge rates of freshwater lenses if the project requires construction of stormwater disposal wells or other means for the conveyance or discharge of stormwater. Additionally, changes in the unconfined aquifer water level could result in a rise in the water table where stormwater is newly infiltrated. To prevent a drop in the water table locally due to infiltration being reduced by new impermeable surfaces, both the infiltration of drainage, and the directing of treated runoff toward recharge areas, could be implemented.

Peat: Impact to peat can possibly be minimised when performing highway maintenance in mangrove areas. This pertains to long-term maintenance, and/or repairs after storms, which may involve vehicles in areas adjacent to the roadway. Protocols for staying on the shoulder and/or working a maximum of 20 ft (6 m) into the mangrove can be developed for potentially contaminative on-site activities and a waste management plan inclusive of emergency situations can be prepared in case of spills and other events that may pollute the area.

Table 11-9: Operation Phase Mitigation for Geo-Environmental Resources

Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental - Aquifer Quality	Tidal flooding, surface water flooding, and extreme weather/climate change-induced flood events	Include protocols for potentially contaminative on-Site activities in the Site EMP. Prepare a waste management plan inclusive of emergency situations.	L	LOD/ OLOD	A	LT	R	NR	Risk of potential aquifer contamination.	Not Significant- mitigation measures would prevent and minimise impacts from flooding.
			A Low magnitude of impact is anticipated. Impacts would occur within and Outside the LOD as once contaminated, groundwater would travel and further infiltrate through aquifers. Timing is Applicable; the impact will vary seasonally. Precipitation increases from June – October, increasing the risk of flooding and extreme weather events. The impact will have a Long-Term duration The frequency will be Regular in accordance with local weather patterns. The impact is Not Reversible as a return to baseline conditions cannot be guaranteed.							

Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental – Freshwater Lenses	Release of contaminants. Changes in recharge could negatively impact hydraulic conditions or degrade recharge quality. Groundwater mixing with infiltrating stormwater could also degrade water quality.	Design measures to maintain water quality in discharged water. Develop pollution prevention techniques. Proper design of the localised drainage systems so that Site discharge to ground and surface water meets applicable water quality discharge criteria.	M	LOD/ OLOD	A	LT	R	NR	Potential contaminant release and potential aquifer pollution.	Not Significant- mitigation measures would limit contamination.
			A Moderate magnitude of impact is anticipated. Local geology and absence of shallow low permeability confining zones might allow contaminants to migrate into aquifers. Areas within and Outside the LOD would be impacted. Timing is Applicable. The impact will vary seasonally. Precipitation increases from June – October, which is when more aquifer recharge is expected to occur, raising the chance of contaminants spreading further. The impact would have a Long-Term duration since the highway is a permanent installation. The frequency of the impact would be Regular. As there would be constant potential for contamination as long as the highway operates. The impact is Not Reversible. Mitigations cannot guarantee a return to baseline conditions.							

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Geo-Environmental – Freshwater Lenses</td><td rowspan="2">Lenses may deteriorate as sources of potable supply if the supporting groundwater flow system loses freshwater volume. This may cause salt-water contamination. Wells might be deteriorated as sources of potable supply.</td><td rowspan="2">Design project to minimise groundwater flow loss. Ensure groundwater flow patterns remain intact and functional.</td><td>L</td><td>LOD/ OLOD</td><td>A</td><td>LT</td><td>R</td><td>NR</td><td rowspan="2">Potential loss of potable supply and increased saltwater intrusion.</td><td rowspan="2">Significant- mitigations can reduce and prevent impacts, but a return to baseline cannot be guaranteed if lenses become deteriorated.</td></tr>
<tr><td colspan="6">A Low magnitude of impact is anticipated.

Areas within and Outside the LOD may be impacted. The karst geology and shallow low permeability confining zone will allow contaminants to enter aquifers.

Timing is Applicable. Seasonal variations may affect the impact. From June – October, precipitation increases, possibly adding to the groundwater flow system's freshwater volume.

The impact duration would be Long-Term since the highway installation is permanent.

The impact will have a Regular frequency in accordance with local weather patterns since infiltration contributes to freshwater volume for the groundwater flow system.

The impact is Not Reversible. Mitigations cannot guarantee a return to baseline conditions.</td></tr>
</table>

Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental – Freshwater Lenses	Groundwater flow loss and changes in flow patterns.	Determine stormwater management options that minimise impacts on lenses. Ensure hydrological regimes are maintained and aquifers are recharged. Design stormwater systems to be effective with rising sea level.	L	LOD/ OLOD	A	LT	R	PR	Potential negative impacts on freshwater lenses and hydrological regimes.	Not Significant- mitigation measures can prevent or minimise substantial changes to hydrologic regimes.
			A Low magnitude of impact is anticipated. Impacts would occur within and Outside the LOD as impacts on hydrologic regimes would occur on a regional scale. Timing is Applicable; impacts may vary seasonally. Precipitation increases from June – October, which is when more aquifer recharge is expected to occur. The impact will have a Long-Term duration. Changes are permanent as long as the highway remains in operation. The frequency would be Regular with local precipitation events. The impact is Partially Reversible. Proper design may help the freshwater lenses and aquifers return to baseline conditions.							

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Geo-Environmental – Freshwater Lenses</td><td rowspan="2">Construction in the lens recharge areas would cause direct impacts. Lenses might have their shapes, configurations, and discharge flow directions changed if discharge areas are disrupted.</td><td rowspan="2">Measures should be taken to minimise impact on freshwater lenses during construction and to preserve discharge flow directions.</td><td>L</td><td>LOD/ OLOD</td><td>A</td><td>LT</td><td>C</td><td>PR</td><td rowspan="2">Potential disruption of freshwater lenses</td><td rowspan="2">Significant- mitigations can reduce and prevent impacts, but a return to baseline cannot be guaranteed if lenses become disrupted.</td></tr>
<tr><td colspan="6">A Low magnitude of impact is anticipated.

Impacts would be felt within and Outside the LOD.

Timing is Applicable; the impact may vary seasonally. Precipitation increases from June – October, which may make it easier for lenses to recharge.

The impact will have a Long-Term duration. Changes are permanent as long as the highway remains in operation.

The frequency would be Continuous; discharge areas would be disrupted due to the permanent change from the highway’s construction.

The impact is Not Reversible. A return to baseline conditions cannot be guaranteed.</td></tr>
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<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Geo-Environmental – Freshwater Lenses</td><td rowspan="2">Increased impervious surface may reduce infiltration and groundwater recharge or redirect stormwater runoff. The water table may rise where water infiltrates. The project may impact drainage patterns and recharge rates if the project requires construction for conveyance of stormwater.</td><td rowspan="2">Design project to facilitate proper infiltration by installing measures to direct stormwater towards recharge points. Design project to minimise the need for construction of conveyance.</td><td>L</td><td>LOD/ OLOD</td><td>A</td><td>LT</td><td>R</td><td>NR</td><td rowspan="2">Potential detrimental changes to freshwater lenses.</td><td rowspan="2">Not Significant- mitigation measures would compensate for lost permeable area and minimise impacts.</td></tr>
<tr><td colspan="6">A Low magnitude of impact is anticipated.

Impacts would be felt within and Outside the LOD as impacts on regional hydrologic regimes would be felt on a large scale.

Timing is Applicable; the impact may vary seasonally. Precipitation increases from June – October, which is when more aquifer recharge is expected to occur.

The impact will have a Long-Term duration. It is a permanent change as long as the highway operates.

The impact frequency will be Continuous; the increased permeable surface is a permanent change.

The impact is Not Reversible. Proper design will help reduce impacts but cannot guarantee a complete return to baseline conditions.</td></tr>
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<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Geo-Environmental – Freshwater Lenses</td><td rowspan="2">The water table level could drop locally if infiltration was reduced due to new impermeable surfaces.</td><td rowspan="2">Design drainage to encourage infiltration and guide runoff in recharge areas.</td><td>L</td><td>LOD/ OLOD</td><td>A</td><td>LT</td><td>R</td><td>NR</td><td rowspan="2">Potential reduction of volume of fresh water in the lenses</td><td rowspan="2">Not Significant- mitigation measures would compensate for lost permeable area and minimise impacts.</td></tr>
<tr><td colspan="6">A Low magnitude of impact is anticipated.

Impacts would be felt both within and Outside the LOD as impacts on the water table would be felt regionally.

Timing is Applicable; impact may vary seasonally. Precipitation increases from June – October, which may make it easier for aquifers to recharge.

The impact will have a Long-Term duration.

The impact frequency will be Regular in accordance with local weather patterns as precipitation provides runoff that infiltrates into the water table.

The impact is Not Reversible. Mitigations will account for otherwise reduced infiltration, but a return to Baseline conditions cannot be guaranteed.</td></tr>
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<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measures</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Geo-Environmental –Brackish Groundwater</td><td rowspan="2">Contamination of groundwater due to contaminant spills and infiltration of road runoff</td><td rowspan="2">Include protocols for potentially contaminative on-Site activities in the Site EMP. A waste management plan should be prepared. Ensure water does not infiltrate into concentrated points.</td><td>M</td><td>OLOD</td><td>A</td><td>LT</td><td>R</td><td>NR</td><td rowspan="2">Potential contamination of brackish groundwater</td><td rowspan="2">Not Significant- mitigation measures would limit contamination.</td></tr>
<tr><td colspan="6">A Moderate magnitude of impact is anticipated. The karst geology and shallow low permeability confining zone will allow contaminants to enter aquifers.

There may be impacts Outside the LOD as groundwater flows and transports contaminants.

Timing is Applicable; Precipitation increases from June – October, causing more runoff and a higher risk of pollution.

The impact would have a long-term duration.

The impact frequency would be Regular, with contamination possible as long as the highway operates.

The impact is Not Reversible.</td></tr>
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Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Geo-Environmental - Peat	The potential release of contaminants may potentially contaminate peat adjacent to the road.	Stormwater management. Develop spill response plans and waste/hauler regulations.	L	LOD	NA	LT	R	NR	Potential contamination of roadside peat.	Not Significant- mitigation measures would limit peat contamination.
			Assuming mitigation measures are applied, the magnitude of the impact would be Low. Impacts would be limited to the LOD. Timing is Not Applicable; seasonal variations are not likely to change the effect. The impact would have a Long-Term duration since the highway operation is permanent. The impact would have a Regular frequency. Contaminants could be released as long as the highway is in operation. The impact is Not reversible. Mitigation would reduce potential contamination but could not completely prevent or reverse it.							

11.4.3 Summary of Geo-Environmental Mitigation Measure Considerations

The mitigation considerations described consist of preventive and best management practices, and various monitoring to reduce impacts during construction. A comprehensive subsurface (i.e., drilling) program during detailed design can determine the underlying stratigraphy so that appropriate measures can be utilised in the applicable locations, such as staging, stockpile, and haul road locations. Preventative and best management measures include spill response plans, chemical/waste hauler regulations, protection equipment for hydrogen sulphide, use of low-impact construction vehicles and/or mats, proper grouting of wells, minimising temporary dewatering excavations, salvaging and reusing mangrove peat, and minimising the use of aggregate fill by elevating roadways (bridges) or other design solutions. Monitoring considerations include aquifer water levels and salinity during construction dewatering as well as other contaminants.

Mitigation measure considerations during operation will consist of measures to prevent and manage impacts. Stormwater management strategies identified during detailed design could ensure that discharges from the site to ground and surface water meet applicable water quality discharge criteria. Elevated structures could minimise flooding in sensitive areas, such as freshwater lens recharge areas (additional information regarding potential bridges and hydrologic features can be found in **Chapter 6: Proposed Project - Engineering Features** and **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**). In addition, pump stations could be used rather than gravity-based systems. Highway maintenance could be completed when peat is least susceptible to compaction. Response plans in case of spills and other emergency situations can help reduce pollution impacts.

Additional information regarding implementation, responsibilities for implementation, any monitoring and reporting, and actions for non-compliance will be included as part of the separate EMP. Due to the phased development of the project, a review of the mitigation measures and design solutions will be continually evaluated during the design, construction, and operation phases to allow for successful mitigation. If the mitigation measure considerations are not implemented, the Large Adverse impact to geo-environmental resources (**Section 11.3.2.3: Overall Assessment Score**) would remain.

12 Hydrology and Drainage, Including Climate Resiliency

As stated in the ToR, the construction of the proposed roadway may impact the natural hydrologic and drainage process. This can lead to effects on adjacent residential properties and natural resources. These effects could be partially avoided or minimised by implementing best management design features that will effectively treat and remove stormwater as well as enable as much as possible the natural hydrological flow patterns by the use of bridges and culverts at designated locations along the corridor.

The assessment of hydrology and drainage will consider effects from a change of water circulation patterns, increase of stormwater runoff volume and velocity, pollution from stormwater runoff, and impact on the ecology of natural resources. The impact on specific resources will be evaluated, including the CMW, Mastic Reserve, Meagre Bay Pond, Freshwater Lenses, Developed Areas, and Drainage Wells.

This Hydrology and Drainage chapter of the ES covers the following:

- Describes the methodology for hydrology and drainage assessments;
- Establishes Baseline Conditions within the Study Area;
- Provides the results of the studies and field assessments for the Proposed Project;
- Identifies the potential benefits and adverse impacts due to the project, including construction and operation phases;
- Assesses the significance of these potential impacts; and,
- Offers avoidance, minimisation, and mitigation considerations for the project's potential negative hydrology and drainage impacts.

This chapter assesses the effects of the Proposed Project described in **Chapter 6: Proposed Project – Engineering Features**. Baseline Conditions, which equate to Existing Conditions, are established to demonstrate the hydrology and drainage environment of the study area defined in **Section 12.2: Baseline Conditions**.

12.1 Assessment Methodology

This section describes the methodology used to assess hydrology and drainage elements during the EIA process. This methodology is in compliance with the ToR and follows established Cayman Islands laws and international standards and practices, which are described in the following subsections.

12.1.1 Applicable Standards and Guidelines

Standards and guidelines were evaluated for use on this project. Sources for these documents included existing Cayman Island regulations, international standards from the UK, Canada, U.S., and global standards. Several standards and manuals are recommended for application on this project (**Table 12-1)** as part of project development through detail design stage. Additional standards and manuals from the UK, Canada and other international standards that were evaluated are listed in **Table 12-2**. Coordination with other government departments is ongoing during the EIA in order to gain concurrence on utilising the above listed standards and manuals. The standards and manuals will be selected and implemented during detailed design. Refer to the **Appendix E – Shortlist [Alternatives] Evaluation: Attachment H – Hydrology & Drainage – Assessment of Alternatives** for more information.

Table 12-1: Recommended Standards and Manuals

Standards and Manuals	Application
• Grand Cayman Planning Department's Grand Cayman Stormwater Management Guidelines	General design of drainage system features.
• Prince George's County, Maryland's Department of Environmental Resources Low-Impact Development Design Strategies: An integrated Design Approach	Guidance in selecting alternative environmental water quality treatment features.
• U.S. FDOT documents ○ Drainage Manual ○ Drainage Design Guide ○ Bridge Scour Manual ○ State of Florida Erosion and Sediment Control Manual	Design detail of drainage and erosion control features and scour design at bridge openings.
• Volume 2 of the Environmental Resource Permit Applicants Handbook for the South Florida Water Management District (SFWMD) • Chapter 62-777 of the Florida Administrative Code currently in use on Grand Cayman	Detailing environmental water quality treatment requirements
• FDOT Standard Specifications for Road and Bridge Construction • FDOT Construction Project Administration Manual • EPA Stormwater Pollution Prevention Plan (SWPPP) Standards and Templates • Volume 1 of the ERP Applicants Handbook for the Florida Water Management Districts	Guidance on managing construction site pollution.

Table 12-2: Additional Standards and Manuals

Standards and Manuals	Application	Source
• General Environmental Health and Safety Guidelines	Guidance on water quality standards.	International
• EIA Directive	Requirements and directives for EIA's.	Cayman Islands
• Ontario Stormwater Management Planning and Design Manual	Guidance on stormwater system design.	Canada
• British Columbia's Stormwater Planning Guidebook	Guidance on stormwater treatment.	Canada
• City of Moncton Design Criteria Manual for Municipal Services	Guidance on stormwater system design.	Canada
• Department for Environment Food and Rural Affairs River Basin Management Plans	Guidance on stormwater treatment.	UK
• Department for Environment Food and Rural Affairs Non-Statutory Technical Standards for Sustainable Drainage Systems	Guidance on stormwater treatment.	UK
• DMRB LA 113 Road Drainage and the Water Environment	Guidance on stormwater system design.	UK

12.1.2 Data Sources Evaluated

A variety of sources of information were evaluated throughout the study process and applicable standards of national and international governmental entities were assessed, as mentioned previously. Technical reports and papers, in addition to data provided by the CIG, were used to develop Baseline Conditions for the overall hydrology and drainage processes and specifically for selected natural resources. Also, the results of the proposed condition modelling were provided by RVE and Baird (**Section 1.5.3: Project Third-Party Consultant**). The data sources utilised are in the References section, including the sources listed as follows (**Table 12-3**).

In addition to the provided resources, the following site visits were conducted for ground truthing and reconnaissance on the island and are detailed further in **Appendix J.7 – Hydrology and Drainage Field Assessment**:

- First site visit in July 2023
- Second site visit in May 2024

Table 12-3: Data Sources

Source	Date Provided	Item
CIG - DoE	November 2022	• Lands protected under the NCA 2013 (*.shp shapefile) • Lands owned by the Cayman Islands NT (*.shp shapefile)
	July 2023	• Central Mangrove Wetland (CMW) (*.shp shapefile) • Mastic Reserve and Mastic Trail (*.shp shapefile)
CIG – Other Departments & Statutory Authorities	August 2023	• LiDAR LAS geospatial data (Appendix J.8 for data limitations) • "Drain Well" shapefile provided by the NRA on August 4, 2023 • Satellite imagery from Google Earth Pro dated between June 5, 2023 to September 15, 2023
RVE and Baird – Hydrology consultants	August 2022	• Hydraulic and Hydrologic Studies of Proposed East-West Arterial Highway Expansion, Memorandum 1 – Preliminary Rainfall Analysis - RVE (Appendix J.1)
	January 2024	• Reference: Pre-Project H&H Studies Related to the Proposed EW Arterial Expansion Project Discussion of Roadway Openings Along the Proposed Alignment - RVE and Baird (Appendix J.4)
	March 2024	• Hydraulic and Hydrologic Studies of Proposed East-West Arterial Highway Expansion, Memorandum 2 – Hydrology and Hydraulic (H&H) Analysis - RVE (Appendix J.2) • Hydraulic and Hydrologic Studies of Proposed East-West Arterial Roadway Expansion, Hydraulic Modelling – Alternatives Assessment - RVE (Appendix J.5)
	April 2024	• Hydraulic and Hydrologic Studies of Proposed East-West Arterial Roadway Expansion, Memorandum 3 – Water Budget Analysis - RVE (Appendix J.3) • Cayman East-West Arterial Extension, Flood Modelling and Roadway Drainage Openings – Final Report - Baird (Appendix J.6)

12.1.3 Constraints and Limitations

This evaluation is primarily based on a review of desktop resources with limited ground truthing. The following limitations and constraints apply to the assessment of hydrology and drainage in this chapter:

- Limited available survey data within the Proposed Project corridor does not provide the level of detail necessary for detailed design.
- Limited geotechnical investigation information regarding the Proposed Project corridor does not provide the level of detail necessary for detailed design.

- Final design standards and regulations baseline requirements has not been fully confirmed by interested parties.
- Modelling performed under attached reports does not cover localized drainage systems and is only at "proof of concept" level for roadway opening structures. Additional detailed modelling and analysis will be required for detailed design.
- Modelling performed under attached reports used LiDAR data provided by the Cayman Islands Lands & Survey Department, which was inconsistent in some areas and contained data processing misrepresentations (i.e., low points were classified as noise, etc.). More information regarding the limitations of the LiDAR data used for modelling can be found in **Section 12.3.5: Coastal Storm Surge and Wave Overtopping Analysis** and **Appendix J.8 - L&S Elevation Data Coordination**.

Due to these limitations, the impacts and mitigation measure considerations in this chapter are considered high level. These elements will be re-evaluated and addressed as part of detailed design of the Proposed Project, which will occur once the EIA is complete.

12.1.4 Assessment of Drainage and Hydrology Impacts

The overall quantitative and qualitative evaluation was based on the UK Department for Transport "Transport Analysis Guidance" (WebTAG), Unit A3. Quantitative variables, such as increase of imperviousness, along with studies including hydrologic and hydraulic modelling, were used to perform the qualitative evaluation. The significance of the effect of hydrology and drainage impacts is dependent on both the sensitivity of the receptor and the magnitude of the impact at the receptor. In addition, construction and operation impacts were further assessed using multiple variables to determine the magnitude of impact, the importance/sensitivity of the impacted resources, and the significance of the impact.

12.1.4.1 Baseline Conditions

Baseline Conditions within the study area (**Figure 12-1**) were assessed to evaluate the existing hydrologic and drainage processes and identify potential receptors. Published data and publicly available information was reviewed to develop the Baseline Conditions considerations. In addition, two field assessments were completed to identify baseline hydrology and drainage elements within the study area and observe natural resources and other items of interest, such as quarries. Information on hydrology and drainage, including topography, climate, tropical storms and hurricanes, storm surge and flood risk, and natural resources including mangroves, the Mastic Reserve, and Meagre Bay Pond, along with estimated climate and land use changes was collected and analysed to define the baseline hydrology and drainage processes and are described in **Section 12.2: Baseline Conditions**.

12.1.4.2 Studies for the Proposed Project

Studies were conducted to provide additional information regarding the hydrology and drainage process to better assess potential impacts and are included in **Section 12.3: Studies for the Proposed Project**. In addition, a groundwater mounding analysis was completed to assess the impact of the Proposed Project on the Lower Valley and North Side freshwater lenses.

RVE and Baird completed hydrologic and hydraulic assessments and drainage modelling to analyse the Baseline and Proposed Project conditions (**Table 12-3**). Studies and modelling effort included:

- an analysis of rainfall intensity, extreme event identification, and rainfall distribution (Razzaghmanesh and Gause, 2022)
- a water budget analysis for the CMW to assess potential hydrologic impacts of the Proposed Project (Gause and Razzaghmanesh, 2023)
- two-dimensional hydraulic analyses modelled Baseline and Proposed Project conditions to preliminarily identify water surface elevations and flooding conditions resulting from rainfall storm events (Gause, 2024)
- coastal flooding study was performed to assess storm surge and wave overtopping for the Baseline and Proposed Project conditions for synthetic and historic (i.e., Hurricane Ivan) hurricane events (Baird and Associates, 2024)

12.1.4.3 Quantitative Impact Assessment

A quantitative analysis was completed to assess potential impacts on the identified receptors, including natural resources, developed areas, and existing drainage infrastructure and is included in **Section 12.4: Project Impacts**. Potential impacts assessed included the following:

- change of water circulation patterns
- increase of stormwater runoff volume and velocity
- pollution from stormwater runoff,
- impact on the ecology of natural resources

12.1.4.4 Qualitative Assessment Methodology

The qualitative assessment for Hydrology and Drainage is based upon the UK Department for Transport's "Transport Analysis Guidance Unit A3: Environmental Impact Appraisal" (WebTAG). The most applicable category for Hydrology and Drainage impacts is "Impacts on the Water Environment". The completed qualitative assessment incorporates WebTAG Section 10 of Unit A3: Environmental Impact Appraisal as appropriate. The qualitative assessment also incorporates the March 2020 DMRB LA 113 as appropriate.

There are three steps in the WebTAG qualitative assessment. The first step is to determine the importance (or value) of features, which includes very high, high, medium, and low. The second step is to determine the magnitude of impact (positive or negative), which includes major, moderate, and minor and also negligible. The third step is to determine the overall assessment score based on the results of Steps 1 and 2. As shown in **Table 12-4**, the assessment scores are based on the magnitude of impact and the importance of the water environment feature and can include large adverse, moderate adverse, slight adverse, and neutral ratings. More information on the qualitative assessment methodology for hydrology and drainage can be found in the **Appendix E – Shortlist [Alternatives] Evaluation: Attachment H – Hydrology & Drainage – Assessment of Alternatives**.

Table 12-4: Assessment Score by Resource

Magnitude of Impact*	Importance of Water Environment Features			
	Very High	High	Medium	Low
Major Negative	Large adverse**	Large adverse	Moderate adverse	Slight adverse
Moderate Negative	Large adverse	Moderate adverse	Slight adverse	Neutral
Minor Negative	Moderate adverse	Slight adverse	Neutral	Neutral
Negligible	Slight adverse	Neutral	Neutral	Neutral

**Identified impacts were adverse, therefore beneficial impacts are not shown within the table*
***Very Large and Large Adverse were merged to be consistent with the 7-point qualitative scale for the Appraisal Summary Table*
Source: WebTAG Unit A3, Environmental Impact Appraisal, Table 15, November 2023

12.1.4.5 Potential Construction and Operation Impacts

Impacts to the identified hydrology and drainage receptors/resources were further assessed based on construction-related and operation-related activities using several attributes and variables, including:

- Likelihood
- Certainty
- Type
- Temporal
- Magnitude
- Sensitivity
- Significance

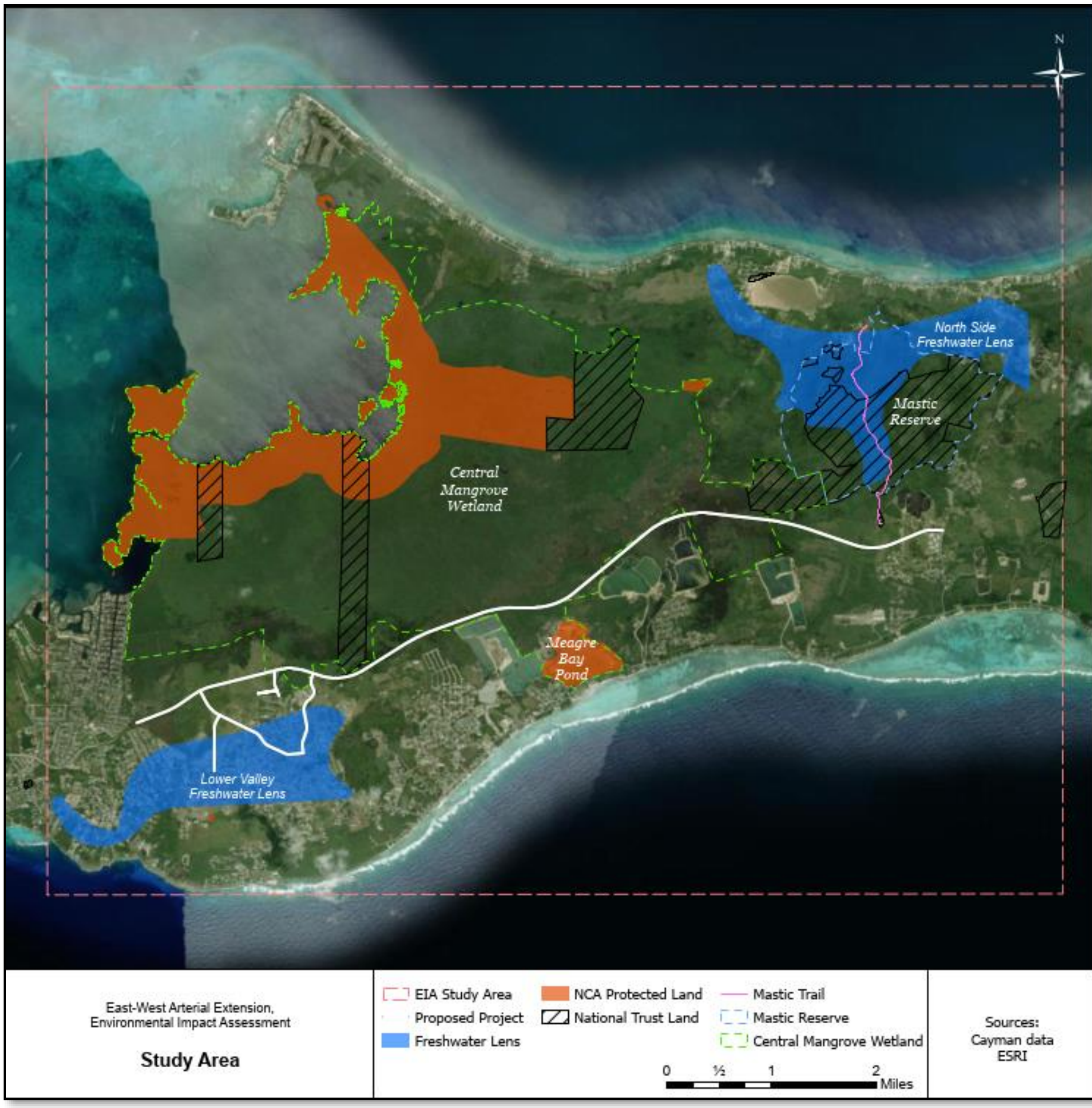
Each impact to an identified hydrology and drainage receptor/resource was evaluated, assigned a sensitivity value, analysed for the magnitude of change on the receptors/resources, and assigned a rating for the significance of the effects. The significance of the effects was determined by the sensitivity of the relevant hydrological feature and the magnitude of change as a consequence of the Proposed Project. In terms of the hydrology and drainage, the key types of effects analysed relate to a change of water circulation patterns, increase of stormwater runoff volume and velocity, pollution from stormwater runoff, and impact on the ecology of natural resources.

The sensitivity of hydrology and drainage receptors/resources analysed for this assessment was related to the importance of the features. The magnitude of change on water receptors is considered independently from the sensitivity since it takes into account potential impacts along with the inclusion of suggested mitigation considerations.

12.2 Baseline Conditions

Baseline Conditions for hydrology and drainage were assessed for the Proposed Project, including topography, climate, tropical storms and hurricanes, and storm surge and flood risk. In addition, the hydrological attributes were assessed for natural resources within the study area, including the CMW, Mastic Reserve, and Meagre Bay Pond. The following sections contain additional information related to the desktop review and field assessment of the Baseline Conditions for the Proposed Project area and the island as a whole. It should be noted that the Baseline Conditions also represent the conditions for the Future No-Build. Additional Baseline Conditions information can be found in the **Appendix E – Shortlist [Alternatives] Evaluation: Attachment H – Hydrology & Drainage – Assessment of Alternatives**. The study area is shown in **Figure 12-1**.

Figure 12-1: Study Area



12.2.1 Topography

Grand Cayman is irregularly shaped with an approximate area of 76 mi^2 (197 km^2). It is approximately 22 mi (35 km) long by 9 mi (14 km) wide at its widest point. The island is relatively flat, low-lying, and has limited concentrated drainage patterns generated by topographic relief (e.g., valleys and rolling terrain). The low-lying topography is vulnerable to winds and flooding caused by hurricanes and tropical storms. The terrain analysis performed as part of the modelling by RVE and Baird identified a few areas where the topography channelizes runoff at the west end of the Proposed Project. These areas, as well as other portions of the Proposed Project footprint, were examined as part of the field assessment. Areas observed during the field assessment, including the areas of slight channelization, were very gradually sloped and it was difficult to determine any discernible existing flow paths. This is in agreement with results of the modelling performed by RVE and Baird, which described the majority of the runoff in the Proposed Project area as gradual, slow-moving flows that were not governed by steep slopes and high velocities. Overall, the Proposed Project is approximately 10 mi (16 km) long and has an ultimate width of 220 ft (67 m), with a slightly larger footprint at intersections and U-turn locations. The topography of the Proposed Project footprint is very similar to the topography of the island as a whole, containing mostly low-lying and gradually sloped land.

12.2.2 Climate

Grand Cayman has a tropical climate that is typically hot and humid throughout the year, with some cooler temperatures during dry season months. The overall average temperature between 2012 and 2021 was 82.7°F (28.1 °C) with the highest average daily temperature of 92.5°F (33.6 °C) and the lowest average daily temperature of 67.4°F (19.7 °C) (Economics and Statistics Office, 2022). The Proposed Project footprint falls entirely into this described climate with no discernible difference between the Proposed Project footprint climate and the island as a whole. The wettest months are typically September and October, while March is the driest month (Razzaghmanesh and Gause, 2022). The average total precipitation from 2011-2021 was 33.9 in (861 mm) a year (Gause and Razzaghmanesh, 2023), with rainfall amounts increasing from east to west due to the evaporation of water in the CMW that is deposited as rainfall in the western side of Grand Cayman. Air temperatures measured at the Owen Roberts International Airport by the National Weather Service between 1971 and 2009 show that average temperatures have increased approximately 3.9°F (2.2°C) over the past 39 years, at a rate of around 0.09°F (0.06 °C) annually (Pinnegar et. al, 2022). In addition, the temperature of the Caribbean Sea has warmed by around 2.7°F (1.5°C) over the last 100 years (Cayman Islands Government, 2013).

The dry, relatively cold months are from late November to mid-April. Dry season cold fronts generate cooler temperatures, stronger winds and rough sea swells known locally as 'Nor'westers', which occur suddenly and can be severe, with sustained wind speeds of up to 46 mph [74 kilometres per hour (km/h)] and gusts up to 69 mph (111 km/h). In the dry season 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 the wet season.

The warm, rainy wet season spans from mid-May through October. In the wet season, weather conditions are influenced by tropical waves, tropical storms, and hurricanes with very intense rainfall. Rainfall is typically the result of tropical thunderstorms or localised rain. Some of the rain is generated from the evaporation of water in the CMW.

Climate and land use changes could affect the hydrology and drainage patterns and 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 the occurrence of extreme weather (e.g., hurricanes). 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). In addition, it has been predicted that annual rainfall totals in the Cayman Islands may decrease between 0.4 and 2 in (10 and 50 mm) between 2011 and 2099 (National Climate Change Committee, 2011). The IPCC predicts that there will likely be a decrease in rainfall during the wet season in the Caribbean area 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, increased evaporation, and extreme weather could impact the hydrology and drainage patterns and the recharging of the island's freshwater lenses.

12.2.3 Tropical Storms and Hurricanes

Hurricanes are a major climatic factor because the Cayman Islands are located within the Caribbean hurricane belt. September, October, and November are typically the most active months for hurricanes, when storms tend to form in the southern Caribbean and move north. The intense tropical storms and hurricanes are typically accompanied by intense rainfall. Storm surges combined with wave action are responsible for much of the damage typically caused by hurricanes, especially in large, low-lying coastal settlements.

More recently, hurricanes have increased in intensity and rainfall, which is potentially a result of warming ocean temperatures and more moisture in the air. Hurricanes have been noted to be 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). Between 1979 and 2017, the global increase in major hurricanes (aka "tropical cyclones") exceedance probability was approximately 8% per decade (Kossin et al., 2020). There have been significant increases in tropical cyclone intensification rates, specifically in the Atlantic basin (Bhatia et al., 2019). The proportion of very intense tropical cyclones (Category 4 and 5) is anticipated to increase globally with increased warming (IPCC, 2021). There is high confidence that rainfall rates in hurricanes will increase by at least 7% per degree of planet warming (Seneviratne et. al., 2021).

12.2.4 Storm Surge and Flood Risk

There are two main categories of flooding that impact Grand Cayman, 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). 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.

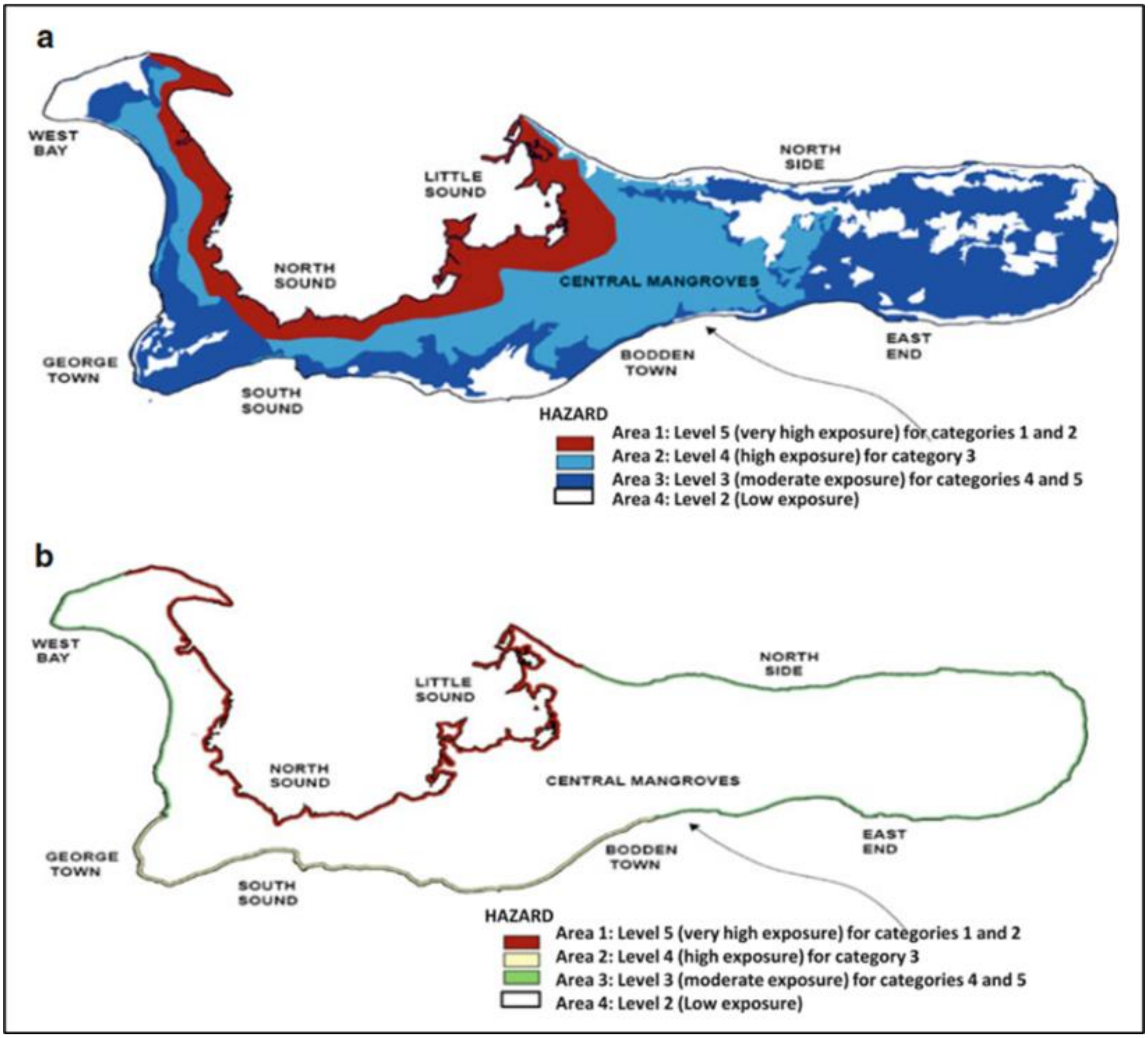
Surface water flooding typically occurs when a tropical depression settles over the island, depositing extreme amounts of rainfall over several days. Due to the generally low elevation and unconcentrated nature of drainage patterns on the island, there are few surface water flow paths, and surface water flooding is typically widespread and of low velocity.

Dense coastal mangrove vegetation on Grand Cayman provides flood protection by intercepting and absorbing rainwater before it reaches the ground runoff conditions, holding back water temporarily and appears to act as a source of friction against moving water, resulting in a reduction of wave heights and peak flows. In addition, mangrove roots trap sediments and soil cohesion are increased by the mangrove root systems, which reduces sediment load in flood waters (Alongi, 2012; Wood Environment & Infrastructure Solutions UK, 2021; Global Nature Fund, 2007).

The level of exposure to hurricanes and associated flooding and storm surge varies along the Proposed Project. Based on the Novelo-Casanova and Suarez (2010) delineated flood zones (**Figure 12-2**), the western area of the Proposed Project near the CMW is within an area of high exposure and the eastern area of the Proposed Project is within an area of moderate exposure for a hurricane approaching from the southeast.

Additional discussion regarding Baseline Conditions and storms approaching from different directions and maximum storm surge impacts are described in **Section 12.3: Studies for the Proposed Project** and the Baird coastal flooding study (Baird and Associates, 2024). In general, the coastal flooding study is consistent with the descriptions above. The study results indicated that slow-moving rainfall runoff drains towards North Sound across the Proposed Project footprint and the slow-moving storm surge moves in from North Sound and drains back northward after the storm surge subsides. The desktop review and field assessments verified the gradually sloped land and dense mangrove vegetation that slows the flow of runoff and storm surge, which is consistent with the modelling analysis.

Figure 12-2: Flood (a) and Storm Surge Areas (b)



Source: Novelo-Casanova and Suarez (2010). Note that the arrow indicates the typical direction of hurricane approach passing south of Grand Cayman.

12.2.5 Central Mangrove Wetland (CMW)

Mangroves are important for both the terrestrial and marine ecology of Grand Cayman as they provide a variety of ecosystem services, such as influencing hydrology and water movement patterns; protection of beaches and coastlines from storm, wave and flood action; reduction of progressive beach and soil erosion; pollution absorption; providing nursery grounds, food, shelter, and habitat for a wide range of aquatic species; and carbon sequestration.

Figure 12-3: Mangroves along North Sound (February 2023)

The normal hydrologic patterns that influence the distribution and growth of existing natural mangrove plant communities include depth, duration, and frequency of tidal inundation and tidal flooding because the hydroperiod (flooding frequency, duration, and depth) regulates biogeochemical processes such as gas exchange (oxygen and CO_2) between plants and the environment, metabolic turnover rates, and the accumulation of sulphide in soil. For the CMW, the tidal pattern is mixed, primarily semi-diurnal, and the average tidal range is approximately 14 to 24 in [35 to 60 centimetres (cm)] (Rigby and Roberts, 1976). Brackish water during high tides influences much of the island, and more than 31 mi^2 (80 km^2) of the island's surface was once covered by mangrove swamp, which is still most extensive around North Sound within the CMW (Woodroffe, 1981). In addition, the salinity of water is also important for mangroves since a change in salinity can change the vegetation species that can grow in that location.

The CMW is part of a large-scale, water flow system which filters and conditions the surface water and shallow ground water that flows into the North Sound while providing a constant flow of nutrients, which form the base of a complex food chain for both terrestrial and marine wildlife (**Figures 12-3 and 12-4**). In addition, the CMW has an important role in the evapotranspiration/precipitation cycle of Grand Cayman, including rainfall generation. An estimated 40% of the rainfall in western districts of the island is believed to be due to evapotranspiration in the CMW (Bradley et al, 2006). 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% (Ng et al., 1992).

Figure 12-4: CMW in the Vicinity of the Proposed Project (May 2024)

The hydrologic and drainage patterns of the CMW change throughout the year. During the wet season months of April through October, the CMW is typically fully inundated with overflows into the North Sound. During the dry season months of November to March, a draw-down of the water surface can occur unless heavy or sustained rainfall or sea water inundation is received. The Lower Valley Freshwater Lens and North Side Freshwater Lens feed into the CMW year-round. Over time, the plant community has adapted to the changing water and salinity conditions in the CMW.

The Proposed Project follows the southern boundary of the CMW and crosses the CMW in a few locations. During the field assessment, the accessible areas of the CMW within the project footprint were investigated, including undeveloped areas within the project footprint and adjacent to the CMW. As shown in **Figure 12-14**, **Figure 12-15** in the Field Assessments section, and the photos in **Appendix J.7 – Hydrology and Drainage Field Assessment**, the portions of the CMW within the site footprint are similar to the rest of the CMW. These areas contained dense mangrove vegetation with a layer of surface peat and varying levels of standing water. As the ground elevation increased on the landward edges of the CMW, the amount of standing water decreased, and the vegetation changed accordingly. There was no observable flowing water in the vicinity of the wetlands explored but rather disconnected low spots containing standing water. The impact assessment in **Section 12.4.1.3: Central Mangrove Wetland (CMW)** discusses the project footprint through the CMW in further detail. Additional information on the CMW is included in **Chapter 13: Terrestrial Ecology**.

12.2.6 Mastic Reserve

The Mastic Reserve, a 1,329 ac (538 ha) ecosystem, 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 (National Trust, 2022). It is located approximately 1,574 ft (480 m) north of the Proposed Project and is generally higher in elevation than the Proposed Project. The Mastic Reserve is included in this analysis as part of the ToR requirements, and although it is not directly within the Proposed Project footprint, it is within the Study Area. In addition, the modelling analyses performed by RVE and Baird indicate that the Mastic Reserve will experience floodwater effects from the proposed roadway construction (see **Section 12.3.1.4: Mastic Reserve** for further detail).

The Mastic Reserve is part of a precipitation/runoff catchment area, absorbing rainfall and gradually releasing it, helping to regulate water flow. Pools and seasonal ponds support diverse aquatic life, including fish, turtles, crustaceans, and waterfowl. The Mastic Reserve is also significant for its role in groundwater recharge. Rainfall is absorbed by the soil, replenishing underground aquifers (North Side Freshwater Lens), and maintaining the island's freshwater supply. A field assessment of the Mastic Reserve from the Mastic Trail was completed in July 2023 and is documented in **Figures 12-5** and **12-6** as well as in **Appendix J.7 – Hydrology and Drainage Field Assessment**. Additional information on the Mastic Reserve is included in **Chapter 13: Terrestrial Ecology**

Figure 12-5: Mastic Trail (July 2023)

Figure 12-6: Mastic Trail – Boardwalk (July 2023)

12.2.7 Meagre Bay Pond

Meagre Bay Pond was designated as an Animal Sanctuary in 1976 to protect resident and migratory birds and then transitioned to a Protected Area designation under the 2013 NCA. It is located approximately 1,291 ft (394 m) from the Proposed Project with a mangrove buffer. Meagre Bay Pond is included in this analysis as part of the ToR requirements and due to the critical nature of this habitat and the proximity of Meagre Bay Pond to the Proposed Project. In addition, the modelling analysis performed by RVE and Baird indicates that Meagre Bay Pond experiences floodwater effects from the proposed roadway construction (see **Section 12.3.1.5: Meagre Bay Pond** for further detail).

Meagre Bay Pond is surrounded with a 300ft (91 m) buffer zone along all sides except the side that borders Bodden Town Road. Sea spray generated by waves breaking on the fringing reef and carried in by southerly winds deposits salt into Meagre Bay Pond year-round. Salt is flushed out of Meagre Bay Pond when prolonged and heavy rains result in surface sheet flow across the CMW to the North Sound.

Meagre Bay Pond is situated on limestone of the Ironshore Formation, which creates a perched water table and has little or no connection to the underlying groundwater or freshwater lenses present on the island. Through the wide beach ridge, Meagre Bay Pond has a highly damped and attenuated connection to sea water; therefore, the water level of Meagre Bay Pond fluctuates due to the seasonality of rainfall. From May to November, rainfall exceeds evapotranspiration and so Meagre Bay Pond water elevation is higher. In the most arid months of March and April, Pond water levels are at their minimum and water salinity is at its maximum. Different water surface elevations from July 2023 and May 2024 are shown in **Figures 12-7** and **12-8**.

Natural and manmade factors that can affect Meagre Bay Pond include climate change, storms/hurricanes, development, and roadway and quarry expansion. The Meagre Bay Pond Management Plan was developed to restore and maintain key ecological functions and facilitate sustainable public use and was approved by the Cayman Islands Cabinet in 2022. Its focus is the maintenance of seasonal hydrology and salinity cycles and facilitating sustainable public use.

Figure 12-7: Meagre Bay Pond, Facing Northwest from Access off Bodden Town Road (July 2023)

Figure 12-8: Meagre Bay Pond, Facing Northwest from Access off Bodden Town Road (May 2024)

12.2.8 Field Assessments

Field assessments were conducted in July 2023 and May 2024 to observe hydrology and drainage conditions on Grand Cayman along with the natural ecological resources within the EIA study area. Hydrology and drainage field investigation efforts included observation and collection of information regarding existing drainage conveyance structures (pipes, inlets, manholes, etc.) along the existing roadway and Proposed Project corridor; observations of the only existing on-island bridge in the Seven Mile Beach Area (**Figure 12-9**); field views of the natural ecological resources (CMW, Meagre Bay Pond, Mastic Reserve/Mastic Trail) and mosquito canals; and a field observation of four of the active quarry operations (**Figure 12-10**). The existing roadways and areas along the Proposed Project corridor were viewed to assess Baseline Conditions and observe drainage patterns (**Figure 12-11**). The existing inlets and drainage systems were identified, mapped, and photographed (**Figure 12-12**). The inlet openings were observed to be approximately 2 ft (0.6 m) by 2 ft (0.6 m) and either contained a vertical pipe drainage well at the bottom of the inlet or drained to another inlet with a drainage well. A rainfall event was also observed and photographed. This event resulted in localized, temporary flooding along Bodden Town Road (**Figure 12-13**). Runoff patterns along the Savannah Gully were also assessed. The mosquito canals were walked and periodically measured (**Figure 12-14**). Two 36-in (1.06 m) Reinforced Concrete Pipes (RCP) were found and had water depths varying between 1.5 to 1.75 ft (0.46 to 0.53 m). The ditches were typically 10 to 15 ft wide (3 to 4.6 m) with water depth generally varying between 1.5 to 2.0 ft (0.46 to 0.61 m). Exposed bedrock was also mapped and photographed (**Figure 12-15**). Details regarding the findings of the field assessment are included in **Appendix J.7**.

Figure 12-9: Existing Bridge in the Seven Mile Beach area (July 2023)

Figure 12-10: Active Quarry (May 2024)

Figure 12-11: Roadway in the Proposed Will T Extension area (May 2024)

Figure 12-12: Inlet on Shoulder Drains to Inlet in Centre of Roadway (July 2023)

Figure 12-13: Flooding on Bodden Town Road after Rainfall Event (July 2023)

Figure 12-14: RCP Drainage Pipe in Mosquito Canals (July 2023)

Figure 12-15: Bedrock Outcrop in the CMW area (May 2024)

In general, the field assessments served to verify the information regarding the project area collected during the desktop review. The existing drainage systems on the island were observed in as many locations as possible and consisted of inlet and drainage well systems, as anticipated. There were also no major existing open surface drainage conveyance systems observed in the developed areas. The portions of the Proposed Project footprint that crossed through undeveloped wetland and upland areas were observed in the field where possible. The wetland areas contained shallow standing water and were gently sloped without well-defined drainage paths, as described in the RVE and Baird reports. The upland areas were similar with gradual slopes along miles of the Proposed Project footprint, leading from lowland areas with shallow standing water to slightly higher elevations that were mostly dry. Most undeveloped areas contained bedrock outcroppings with some upland areas being covered almost entirely in bedrock and most of the wetland areas containing a layer of peat periodically broken up by bedrock outcroppings. Overall, the conditions that were able to be observed within the Proposed Project footprint appeared to be generally consistent with the modelling analysis performed by RVE and Baird and with the Baseline Conditions contained within this analysis.

12.3 Studies for the Proposed Project

12.3.1 Overview

A conceptual groundwater mounding analysis was performed by WRA and analyses by RVE and Baird were completed to provide additional information on the hydrologic and drainage processes on Grand Cayman in order to evaluate the potential impacts during the Shortlist Alternatives Evaluation (**Appendix E – Shortlist [Alternatives] Evaluation: Attachment H – Hydrology & Drainage – Assessment of Alternatives)**. The study results and the general findings from these analyses are applicable for the Proposed Project. The analysis included the appropriate, large scale hydraulic and hydrological components of the Proposed Project for the current stage of development. These assessments included: 1) an analysis of rainfall intensity, extreme event identification, and rainfall distribution (Razzaghmanesh and Gause, 2022); and 2) a water budget analysis for the CMW to assess potential hydrologic impacts of the Proposed Project (Gause and Razzaghmanesh, 2023). Two-dimensional hydraulic analyses modelled the Baseline Conditions and the Proposed Project to preliminarily identify water surface elevations and flooding conditions resulting from rainfall storm events (Gause, 2024). In addition, a coastal flooding study was performed to assess storm surge and wave overtopping in Baseline and Proposed Project conditions for synthetic and historic (i.e., Hurricane Ivan) hurricane events (Baird and Associates, 2024). Although the Proposed Project is not located in an area vulnerable to wave overtopping, the modelling results are described in their relation to the challenges faced by a road that traverses the coastline, such as the existing Bodden Town Road, a coastal road. **Figure 12-16** includes the modelled bridge openings along the Proposed Project, which were used for the hydraulic modelling.

Figure 12-16: Modelled Bridge Openings

A memo written by RVE and Baird explained that the two teams used different roadway opening configurations in their modelling (**Appendix J.4**). The memo further recommended that the RVE opening configuration be utilised moving forward as they present a more conservative approach (i.e., more and longer openings than the Baird model). The memo also indicated that the differences in opening configuration should not be considered contradictory because the analysis is at a proof-of-concept level and will require significant development and detailed refinement by both engineering and hydrologic and hydraulic modelling during the future detailed design stages of project development. Following this guidance, the opening configuration shown above and used as part of the Proposed Project development matches the configuration used in the RVE model; however, the RVE modelling only covered non-hurricane rainfall events and the Baird modelling covered the larger, hurricane induced surge and rainfall events that may control design of the roadway openings in the detailed design analysis. Therefore, the modelling results for maximum impoundment levels and duration of impoundment reported in later sections are from the Baird models.

The modelled bridge openings were preliminarily identified as part of the RVE hydrology and hydraulic analysis and are shown on **Figure 17** of **Appendix J.2 Hydraulic and Hydrologic Studies of Proposed East-West Arterial Roadway Expansion** (Razzaghmanesh and Gause, 2024); the openings were placed based on minor variations in the local topography. The opening locations were then further refined, as modelling progressed, to be located in areas of specific flooding concerns (Baird and Associates, 2024; and Gause, 2024). Overall, the modelling effort performed was at a proof-of-concept level. The opening configuration and model details will require further refinement in the detailed design analysis (Gause, 2024).

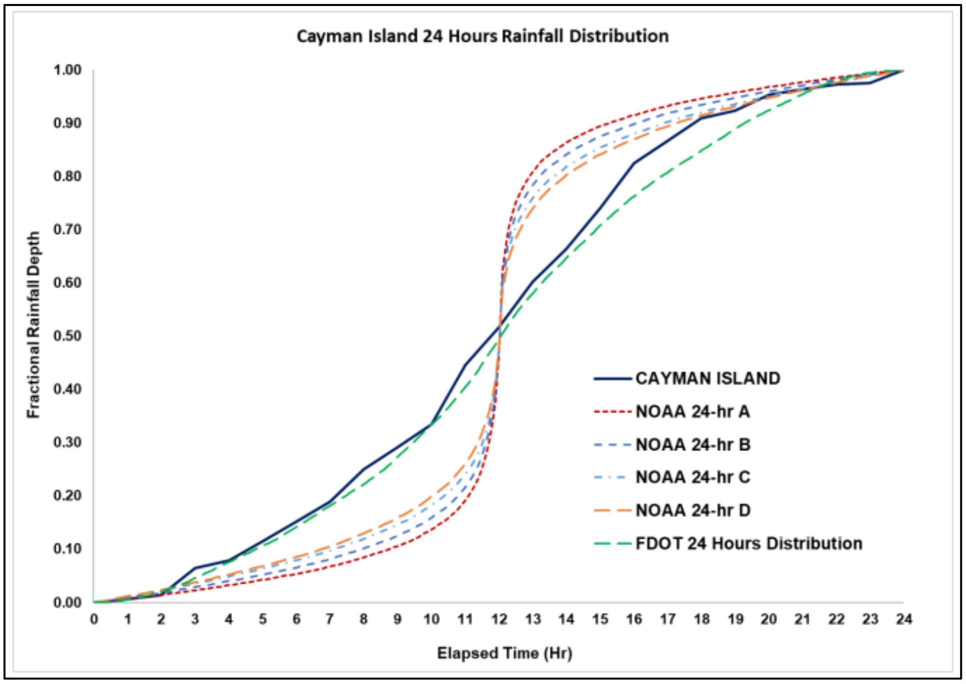
Another consideration for the bridge opening configuration is to ensure that natural water flows are maintained as much as possible, and negative environmental impacts are minimised, such as hydrologic disconnection of wetlands or isolation of Meagre Bay Pond. These concerns were considered when placing structure locations to ensure the larger conveyances are maintained, such as locating an opening along the historic northern flow path from Meagre Bay Pond to the CMW. Locations of hydrologic isolation of wetlands and other areas will need to be identified as part of the detailed design analysis; however, these smaller magnitude flows could be accommodated with smaller, piped culvert crossings that could be placed in later stages of design. Openings, such as bridges and culvert crossings, minimise the hydrologic impact of the Proposed Project.

12.3.2 Rainfall Analysis

A rainfall analysis, including intensity analysis, extreme event identification, and rainfall distribution analysis was completed for the EWA EIA study area by RVE (Razzaghmanesh and Gause, 2022). A summary is provided below, and the full study is in **Appendix J.1**.

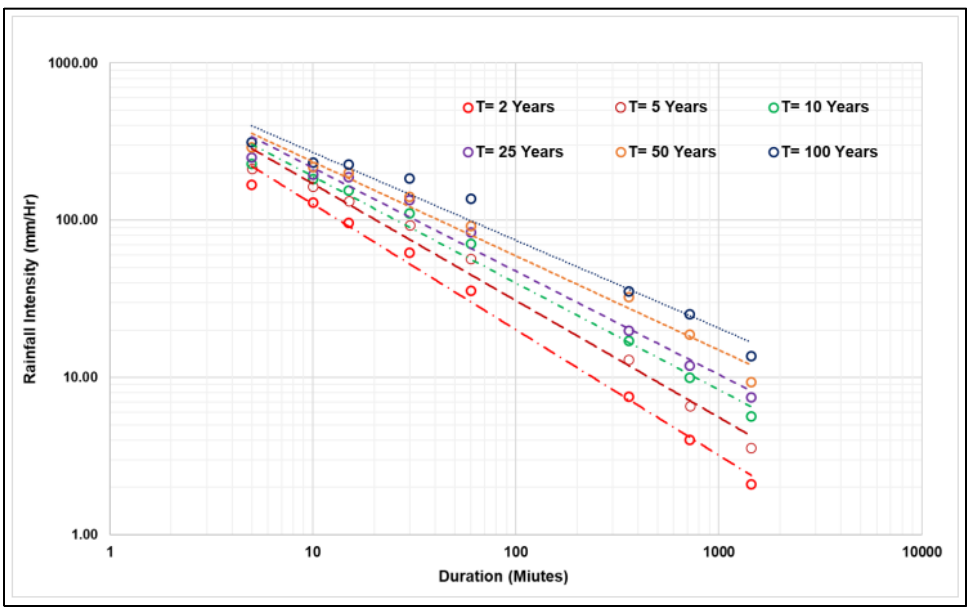
Daily (24-hour) rainfall data collected by sixteen WAC rain gauges between 1982 and 2021 was used to determine the maximum daily (average 24-hour) rainfall intensity and identify extreme events. Hourly data from four weather stations was used to create events for the rainfall distribution analysis (**Figure 12-17**) to develop Intensity-Duration-Frequency (IDF) curves (**Figure 12-18**). The associated rainfall intensities and return periods were calculated for the generated time series durations and used to develop the IDF curves.

Figure 12-17: Grand Cayman Rainfall Distribution



Source: Razzaghmanesh and Gause, 2022

Figure 12-18: Intensity-Duration-Frequency (IDF) Curves



Source: Razzaghmanesh and Gause, 2022

12.3.3 Rainfall Hydrology and Hydraulic Analysis

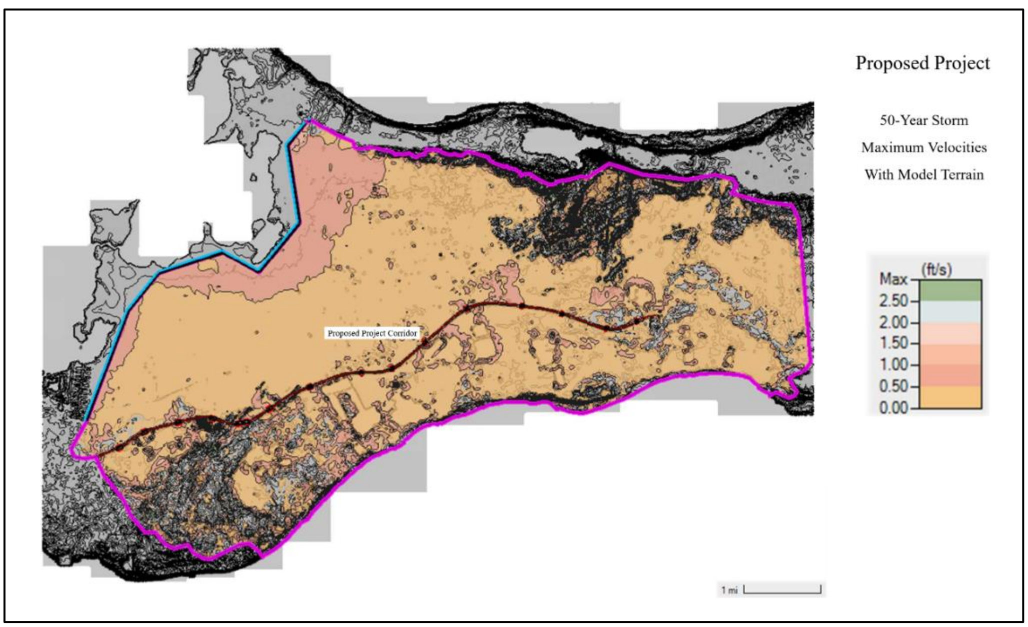
A hydrology and hydraulic analysis was completed for Baseline Conditions and the Proposed Project by RVE (Razzaghmanesh and Gause, 2024; and Gause, 2024). The constraints and limitations listed in **Section 12.1.3: Constraints and Limitations** are applicable for this analysis.

A summary is provided below, and the full study is presented in **Appendix J.2 and J.5 Hydraulic and Hydrologic Studies of Proposed East-West Arterial Roadway Expansion**.

Analysis of the Future No-Build is associated with the Baseline Conditions. The analysis utilised the results of the rainfall analysis described above as well as land use data and terrain modelling to develop a two-dimensional hydraulic model and inundation flood maps for different rainfall events. The Hydrologic Engineering Centre River Analysis Program (HEC-RAS 2D) was used to develop two-dimensional flood maps applying the diffusion wave equation and inputs, including delineated drainage area, hydrographs, land use, infiltration, and Manning's coefficients. Rainfall scenarios included 2-year, 10-year, 25-year, 50-year, and 100-year for a 24-hour event and the 2004 Hurricane Ivan. Both the Baseline and Proposed Project conditions were modelled.

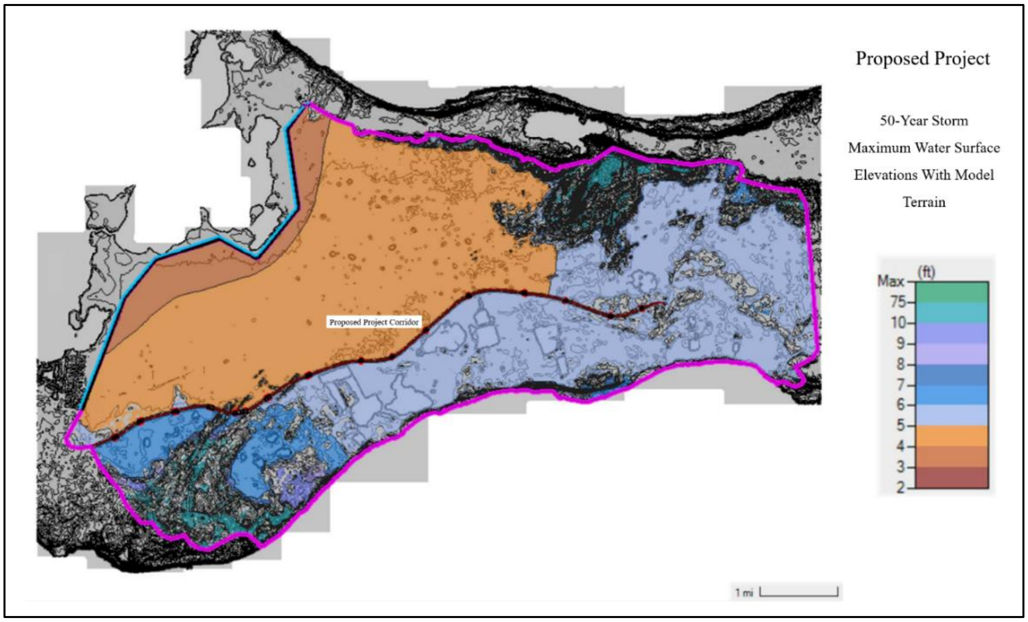
Maximum velocities, water surface elevations, and depths along the Proposed Project were modelled based on 50-year storm parameters without sea level rise consideration (**Figures 12-19, 12-20,** and **12-21**). Modelled flow velocities adjacent to the proposed roadway are generally less than 0.5 ft/s (0.2 m/s) north and south of the Proposed Project, with limited areas of 0.5 to 2.5 ft/s (0.2 to 0.8 m/s). The modelled maximum water elevations adjacent to the proposed roadway are generally higher south of the Proposed Project (approximately 5 to 7 ft (1.5 to 2.1 m) than north of the Proposed Project (approximately 4 to 6 ft (1.2 to 1.8 m). In addition, maximum water elevations adjacent to the proposed roadway are highest in the western area of the Proposed Project (approximately 7 to 8 ft (2.1 to 2.4 m)). The modelled maximum water depths adjacent to the proposed roadway are generally deeper south of the Proposed Project (approximately 1 to 3 ft (0.3 to 0.9 m)) than north of the Proposed Project (approximately <1 to 2 ft (0.3 to 0.6 m). In addition, maximum water depth adjacent to the Proposed Project is highest just north of Dominica Drive (approximately 3 and 4 ft (0.9 to 1.2 m)).

Figure 12-19: Grand Cayman 50-Year Storm Maximum Velocities with Model Terrain



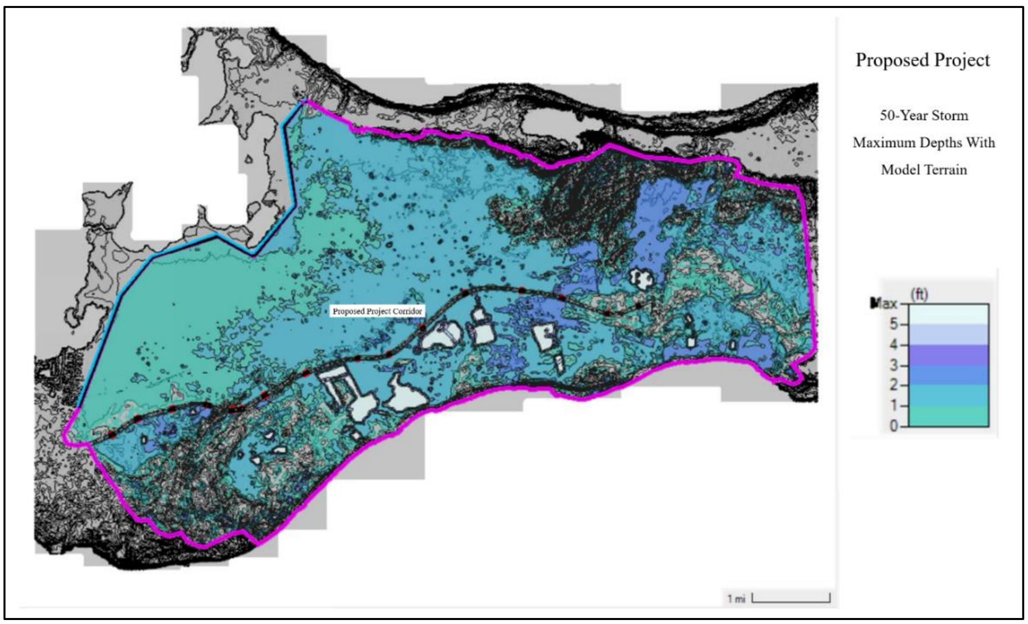
Source: Razzaghmanesh and Gause, 2024

Figure 12-20: Grand Cayman 50-Year Storm Maximum Water Surface Elevations with Model Terrain



Source: Razzaghmanesh and Gause, 2024

Figure 12-21: Grand Cayman 50-Year Storm Maximum Depths with Model Terrain

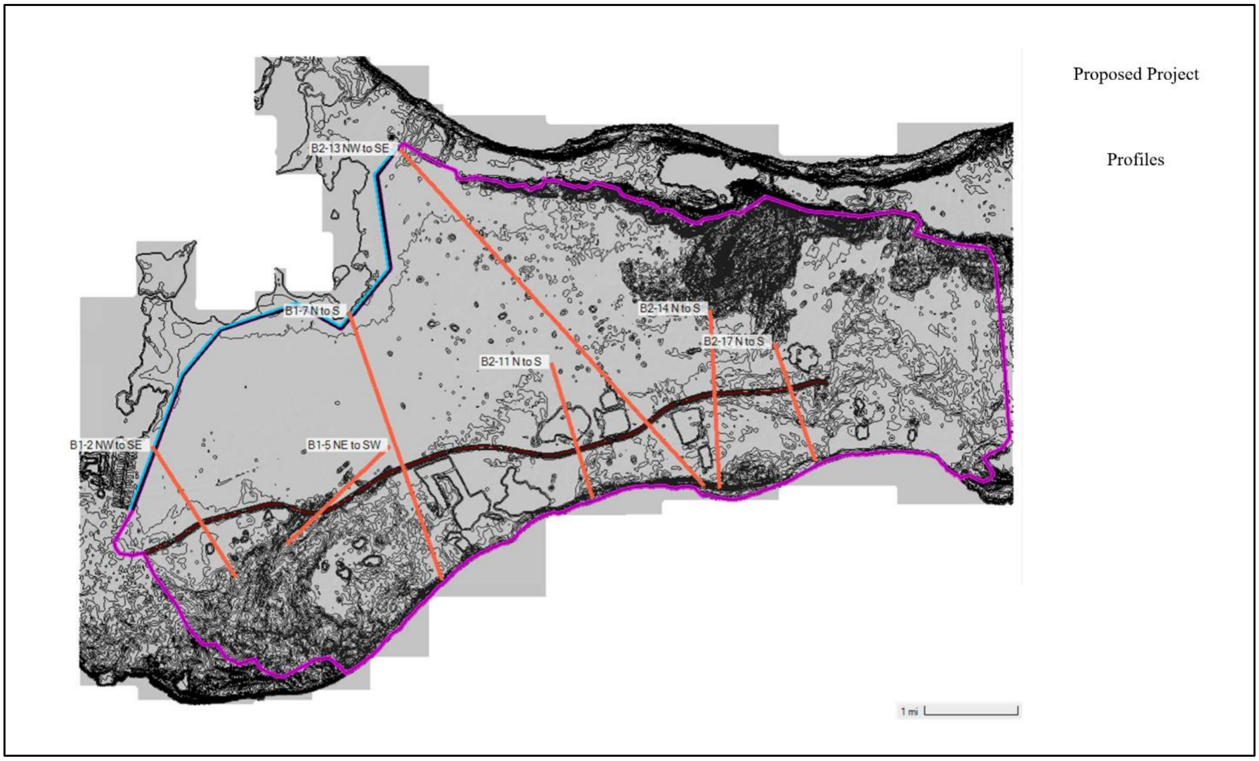


Source: Razzaghmanesh and Gause, 2024

The results, generally referred to as rainfall flooding, show minor differential rainfall flooding, or what is described as roadway embankment impounding, for the smaller storms, such as the 2-year storm. Larger storms, such as the 50-year and 100-year storms, had impoundment differentials of 1 to 2 ft (0.3 to 0.6 m). The largest areas of potential floodwater impoundment occur on the western end of the Proposed Project where topography channelized rainfall would runoff towards the proposed new road with only the opening under the road as an outlet location. This impoundment situation can potentially be mitigated by the location(s) and size(s) of the roadway openings in this area of the proposed new roadway.

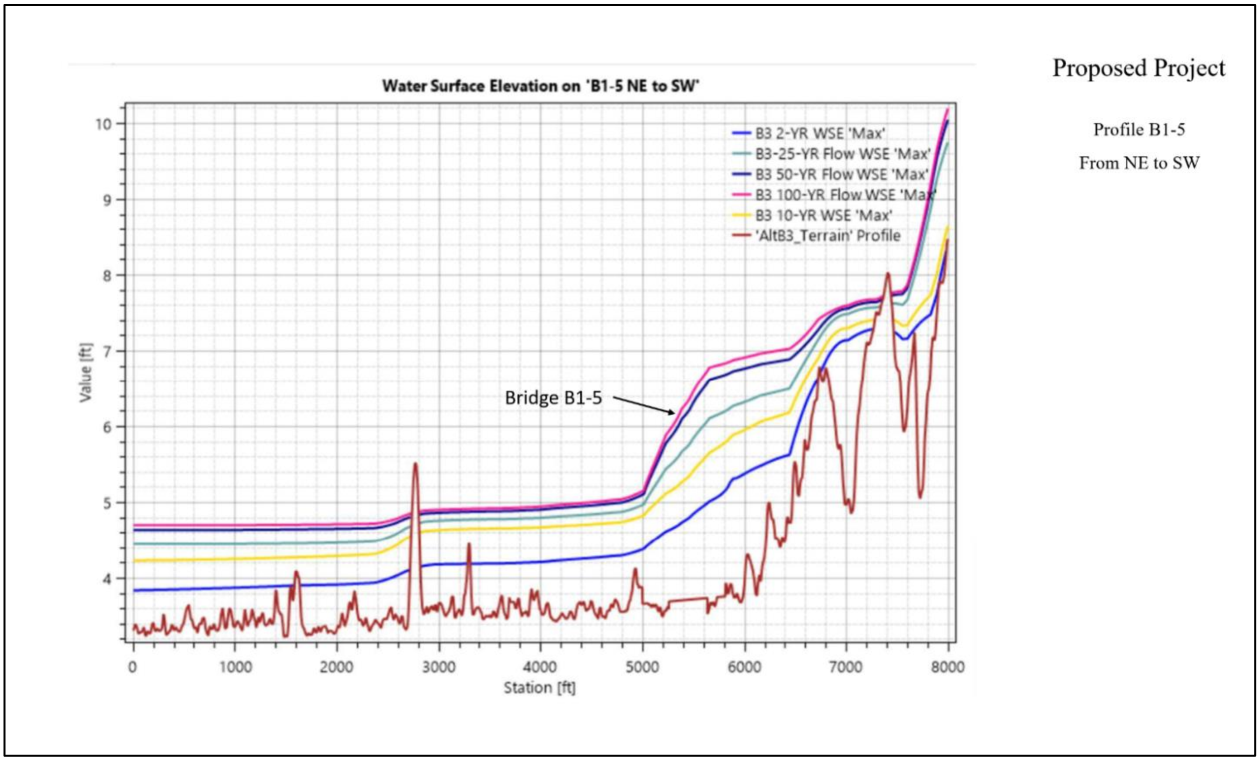
An example of the floodwater impoundment is provided below. Cross section B1-5 is located in the western side of the Proposed Project and includes a 300 ft (91 m) long bridge and cross section B2-14 is located in the eastern side of the Proposed Project and includes a 150 ft (46 m) long bridge (**Figure 12-22**). Note that although Alternative B2 from the Shortlist Alternatives Evaluation is shown on the cross-section map, the selected cross sections are located where the Alternative B2 and the Proposed Project are similar. Therefore, the results of the analysis are presumed to be applicable to the Proposed Project. As shown in **Figure 12-23**, water is impounded on the southern side of the proposed roadway for cross section B1-5 while minimal impoundment occurs for cross section B2-14 (**Figure 12-24**).

Figure 12-22: Proposed Project Profiles



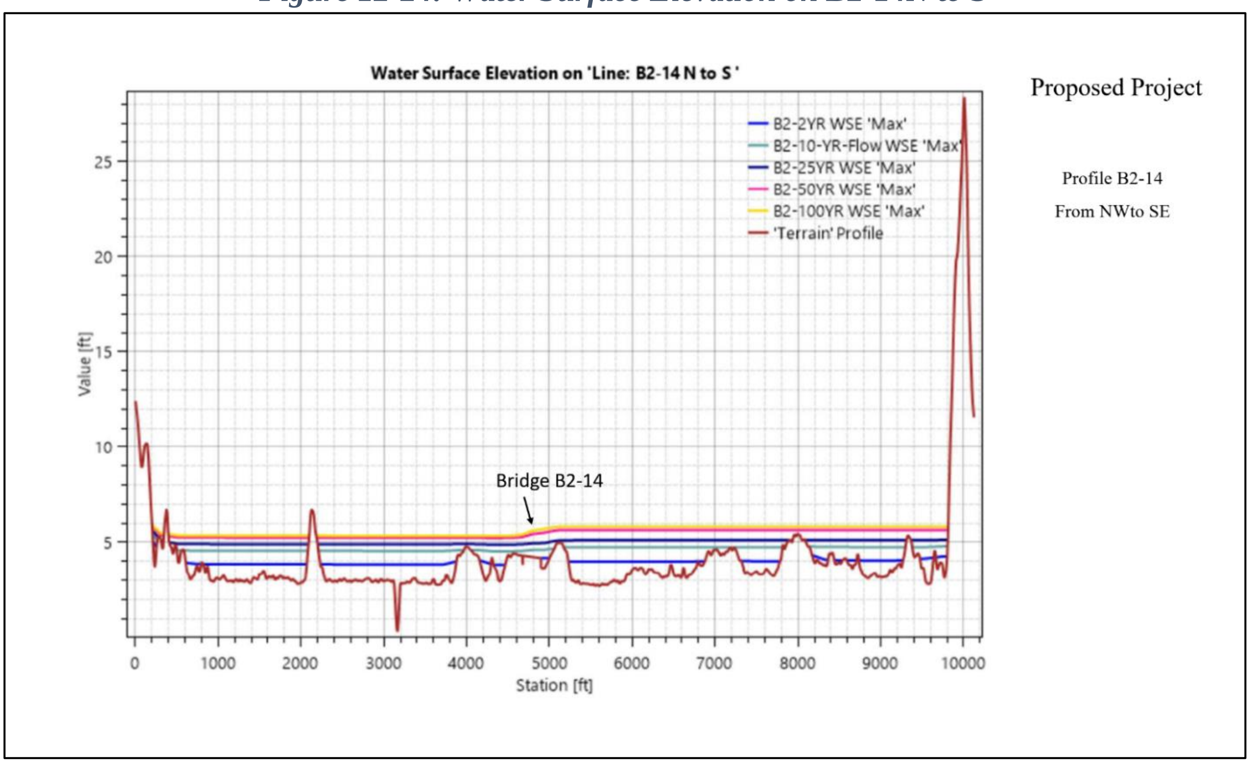
Source: Razzaghmanesh and Gause, 2024

Figure 12-23: Water Surface Elevation on B1-5 NE to SW



Source: Razzaghmanesh and Gause, 2024

Figure 12-24: Water Surface Elevation on B2-14N to S



Source: Razzaghmanesh and Gause, 2024

12.3.4 Water Budget Analysis for Central Mangrove Wetland (CMW)

A water budget analysis for Baseline and Proposed Project conditions was completed for the CMW in the vicinity of the Proposed Project by RVE (Gause and Razzaghmanesh, 2023). A summary is provided as follows. Additional information is in **Appendix E – Shortlist [Alternatives] Evaluation: Attachment H – Hydrology & Drainage – Assessment of Alternatives** and the full study is in **Appendix J.3**.

The study found that the wetland pool occasionally draws down when the monthly precipitation is lower than normal, particularly in the dry season if there is no heavy or sustained rainfall or high sea water flowing into the CMW. The pool likely shrinks from the higher ground towards the deeper areas along the North Sound. In the past, drought periods have caused extensive drawdowns in the CMW. In addition, large storm events have resulted in saltwater flooding and waves along with high winds. The wetland habitat and species have evolved during these periods of dryness and disturbance wherein the CMW sustains damages and then recovers.

It was determined that the CMW pool and water level would not be significantly impacted by the proposed new roadway despite the small increase in the total runoff curve number for the drainage area analysed. The relatively small increase in runoff from the Proposed Project in the overall large watershed is not reflected within the accuracy of the analysis. For both Baseline and Proposed Project conditions, most rainfall within the CMW study drainage area is consumed by evapotranspiration. In addition, Proposed Project conditions are anticipated to be identical to Baseline Conditions and of the 33.9 in (86mm) of average annual rainfall, 11.4 in (289 mm) becomes runoff, 0 in (0 cm) is infiltrated from the Lower Valley Lens into the CMW, and 71.4 in (1814 mm) is utilised by evapotranspiration in the study drainage area of the CMW. Evapotranspiration is higher than rainfall since the mangroves utilise water from other sources, including groundwater and pooled water.

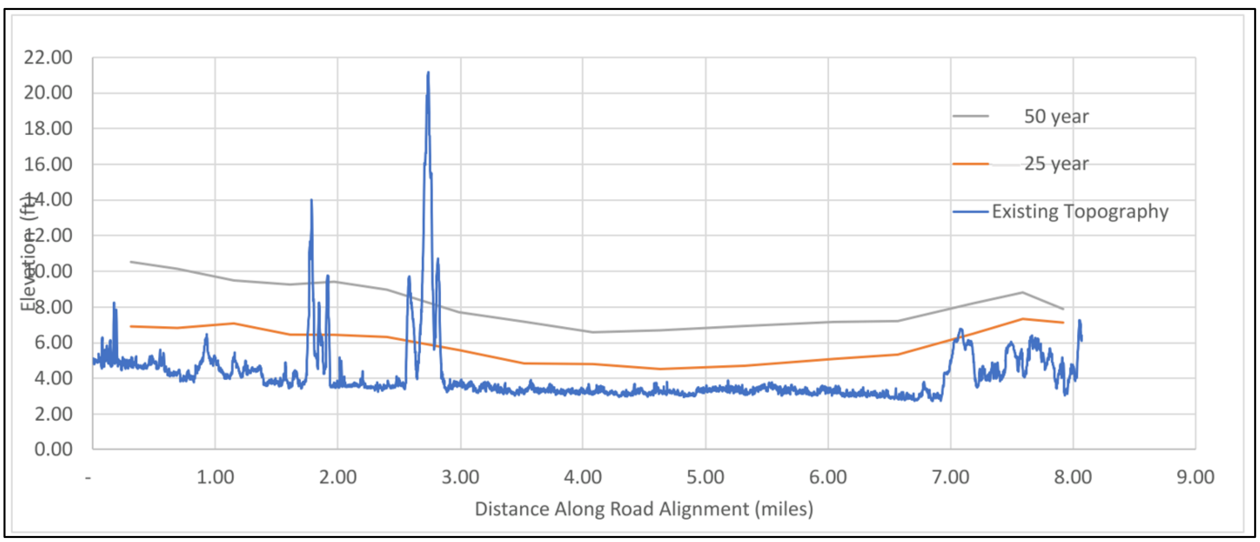
12.3.5 Coastal Storm Surge and Wave Overtopping Analyses

A Coastal Risk Study was completed for the Proposed Project (Baird and Associates, 2024). This study includes the results of storm surge (originating in the North Sound) and the wave overtopping (along the southern shoreline) analyses. The storm surge study stated that this analysis included hurricane-induced flooding, whereas the RVE analysis included the impacts of non-hurricane rainfall events. Lower return period flooding events are likely defined by rainfall only, while events of 10 to 20 years or longer are likely combined flooding from hurricane induced rainfall and surge. The Future No-Build is associated with the Baseline Conditions presented within the surge analysis. Extreme flooding due to tropical storms and hurricanes, including the effects of tide, storm surge, waves, and rainfall, were numerically modelled. Baird did not model sea level rise for this study but recommended that sea level rise be considered during the detailed design of the road as part of a general review of uncertainty in modelling results, construction cost implications, and ability to adapt in future decades if required. Page 8 of the study noted that, "as a general rule, a rise in sea level of a given amount will result in flood levels increasing by a similar amount in the project area". The complete study can be found in **Appendix J.6**. A summary of the analysis is provided as follows.

The proposed new roadway conditions were modelled using the proposed roadway design in addition to the baseline roadway conditions, which were modelled with the current island topo-bathymetry without the proposed roadway corridor in place. The study noted that the provided LiDAR data had a discontinuity at the seaward extent of the mangroves, which suggests that penetration into the mangroves was inadequate. The study also noted that the originally provided data included features such as buildings and vehicles on the road and that it appears many of the points classified as “ground” did not fully penetrate to the ground. To remedy this issue, the study reduced the LiDAR data by 2.46 ft (0.75 m) in elevation for mangrove areas identified through government datasets. The study noted that this adjustment needs to be validated in the detailed design analysis.

For the project, the analysis simulated 484 synthetic tropical storm and hurricane level storms. The simulations were completed using the Telemac model with wind fields developed using a modified version of the Holland et al. (2010) wind profile and rainfall developed using Bader’s 2019 framework. The results of the 484 synthetic storms were used to develop a statistical database of storms on the island that could be used to define storm return periods (50-year storm, 100-year storm, etc.). This is due to the fact that better defined historical storms are limited to the past few decades and the small number of these storms is insufficient for defining longer return periods. The return periods defined from the statistical data included 20-year, 25-year, 30-year, 40-year, 50-year, 75-year, and 100-year return periods. **Figure 12-25** shows the 50- and 25-year water surface profiles for the Proposed Project.

Figure 12-25: Return Period Levels Along the Proposed Project



Source: Baird and Associates, 2024

Of the 484 synthetic storms modelled, seven representative storms were selected to be run in models that included the geometry and roadway openings of the shortlist roadway alternatives. Information on the seven selected storms is provided in **Table 12-5** below.

Table 12-5: Selected Storms for Simulation of Shortlist Alternatives

Event	Location	Surge (m)	Rank	Return Period (yr)	Rainfall Parameters	Path
1115	West	3.6	1	485	Total 1226 mm	N of site, moving to WNW
	Middle	4.1	2	243	Peak rate 39 mm/hr	
	East	4.3	1	485	Hrs>2.5mm: 45	
2848	West	2.2	4	121	Total 2135 mm	N of site, moving to WNW
	Middle	3.0	5	97	Peak rate 39 mm/hr	
	East	3.7	3	162	Hrs>2.5mm: 74	
4492	West	2.1	6	81	Total 1106 mm	N of site, moving to WNW, weaker & closer to site than 1115 & 2848
	Middle	2.7	8	61	Peak rate 38 mm/hr	
	East	2.3	7	69	Hrs>2.5mm: 42	
4184	West	0.8	16	30	Total 1496 mm	N of site, moving to WNW, further away than 1115 & 2848
	Middle	1.8	14	35	Peak rate 39 mm/hr	
	East	2.8	4	121	Hrs>2.5mm: 58	
5031	West	1.5	9	54	Total 1051 mm	S of site, moving to WNW, but passing close-by
	Middle	2.3	9	54	Peak rate 38 mm/hr	
	East	1.2	32	15	Hrs>2.5mm: 45	
5005	West	1.0	14	35	Total 1224 mm	NE of site, moving to NW, closer but weaker storm
	Middle	1.9	13	37	Peak rate 35 mm/hr	
	East	2.0	11	44	Hrs>2.5mm: 54	
2977	West	0.7	17	29	Total 1226 mm	Almost directly over site, moving to WNW
	Middle	1.4	35	14	Peak rate 37 mm/hr	
	East	1.0	67	7	Hrs>2.5mm: 52	

Source: Baird and Associates, 2024

These storms are approximately ranked by surge severity, though the severity varies by location along the Proposed Project. The storm severity for the Baseline Conditions was determined by the surge level simulated at three locations in the project area (west, middle and east). The rank of the storm at each of these locations is provided in **Table 12-5**, in addition to rainfall parameters and the general description of the path of the storm. The surge, rank, and return period values in **Table 12-5** provide general guidance on the relative severity of the different storms in different regions of the study area. The west, middle, and east locations are general areas with no clear transition and have variability throughout the area. The study notes that the modelled storms are example storms and actual storms may be similar or different from the modelled storms, which is the reason more detailed statistical analysis relies on hundreds of storm events.

The maximum flood level and flood durations from these seven representative storms were then averaged and included in tables within the study area for the identified locations of interest (developed areas, CMW, Meagre Bay Pond, etc.). These average maximum flood level and flood duration comparison tables are the source of the data for the maximum impoundment and impoundment duration tables in later sections that are used to evaluate the flooding along the Proposed Project.

Model results indicate that the Proposed Project would mostly be affected by storm surge coming from the North Sound. The model results indicate that the roadway profile, with a modelled low-profile elevation close to 6 ft (1.8 m) above mean sea level, would not be overtopped by a moderate storm event (25-year) but would be overtopped by larger events (100-year). The model also demonstrates that the floodwaters would experience a slight reduction in peak flood elevations in some locations and a slight increase in the length of time required to drain the floodwater in some locations. The results also indicate that the western portion of the proposed new roadway, stretching from existing Woodland Drive to Lookout Road and referred to as Section 2, contains more topographical relief than the rest of the project area and is subject to a higher water level on the south side of the road due to the impoundment of rainfall. This water impoundment may require a number of openings along the proposed new roadway in this area to reduce flooding impacts. It should be noted that the study included recommendations for roadway profile and opening structure configurations; however, this information was developed during the initial phases of the study and was superseded by the modelling analysis performed and referenced in this report.

Additional design guidance for the roadway and openings was provided as part of this study. It is recommended that the roadway elevation is increased near bridges and that the underside of the structure spanning the roadway opening be elevated to at or above the level of the road on either side of the structure to improve drainage. During a large flood the road will act as a weir and allow large volumes of water to pass over it, but the weir becomes much less effective as the water level recedes closer to the elevation of the road and significantly impedes the water flow.

The modelled roadway openings had a base (invert) elevation of +1.6 ft (0.5 m). A higher opening elevation will reduce ponding while a lower opening elevation will provide greater conveyance but will increase ponding of water. For the opening structure geometry, gradually flared ends provide lesser entrance/exit losses when compared to abrupt square ends.

In the base of the openings, scour protection may need to be provided. Smooth scour protection is preferred as it will increase the conveyance of the opening while rough (large diameter riprap) will decrease conveyance. For the side slopes and shoulders of the roadway, erosion control/armouring is suggested to prevent erosion damage along the road when the road is overtopped by flood waters. In addition, it is suggested that opening abutments, if used, are armoured.

Wave overtopping was also analysed along the southern coast of the island using adjusted results from the CSHORE and XBEACH numerical model as part of this study. The Proposed Project is located further inland and was determined to not have significant effects from wave overtopping. Results from the wave overtopping analysis could be applied to the existing coastal roadways, such as Bodden Town Road. The model results were also compared to existing imagery and data for the overtopping that occurred along coastal roads due to Hurricane Ivan. The model results allowed wave overtopping elevations to be correlated to return periods and demonstrated that the Hurricane Ivan results were likely more than the 100-year event. The study further detailed that wave overtopping would not only require coastal road closure due to standing water on the road but also involve sediment deposition on the road, requiring a much longer time to clear and re-open the road.

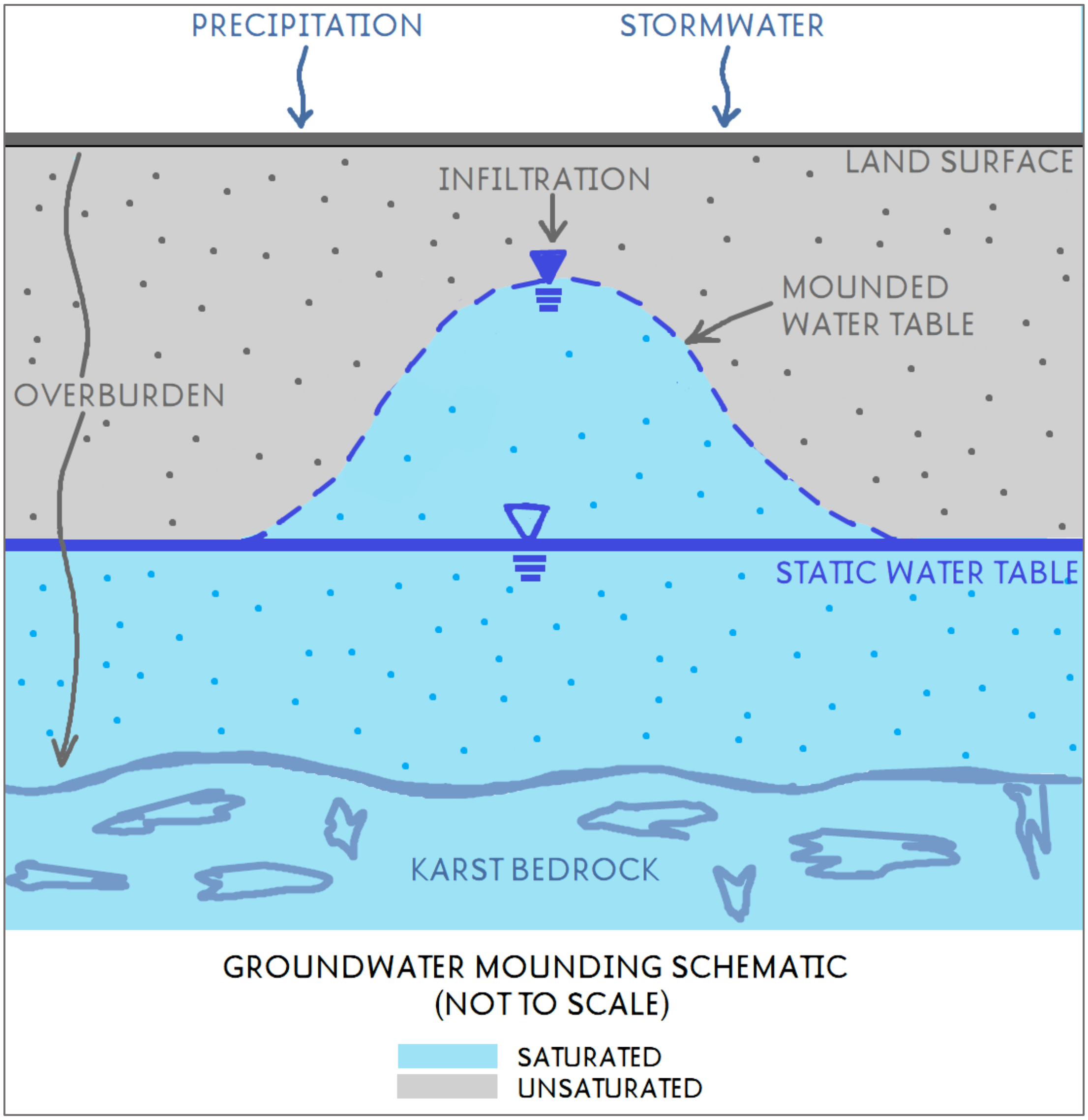
In summary, the coastal storm surge and wave overtopping analysis performed by Baird models the effects of a storm surge driving water into the CMW through the North Sound and the widespread flooding and extended drawdown that would ensue (Baird and Associates, 2024) and was one of the driving factors in the analysis of the roadway bridge openings in order to effectively convey this surge flow without creating significant increases in the peak or duration of floodwaters. As discussed in **Section 12.3.1: Overview**, the roadway bridge opening configuration from the RVE model was used for the Proposed Project development; however, the impoundment analysis values reported were from the Baird model. The analysis also described the wave overtopping impacts along the southern shore, specifically covering the impacts from Hurricane Ivan in 2004. The analysis referred to aerial imagery from this time showing the massive movement of sand from the beach and up onto the existing Bodden Town Road. This movement of sand and the time required to clear it creates a major concern for the accessibility of coastal roadways following a storm event, as described in the above sections.

12.3.6 Groundwater Mounding Analysis

An assessment was performed to identify the impact of the stormwater modelling runoff on the upper surface of the freshwater lenses, including the Lower Valley Freshwater Lens and the North Side Freshwater Lens. Groundwater mounding is the localized short-term rise in the groundwater table that occurs when the recharge rate is higher than the capacity of the aquifer or soil to convey the water out of the recharge zone. A summary of the groundwater mounding analysis is as follows, and the full study is in the **Appendix E – Shortlist [Alternatives] Evaluation: Attachment H – Hydrology & Drainage – Assessment of Alternatives**. Detailed information regarding the Freshwater Lenses can be found in **Chapter 11: Geo-Environmental**.

Based on the Baird modelling results, a rise in water level of 0.2 ft (0.06 m) over a duration of 10 hours was associated with the runoff for both groundwater mounding assessments. Groundwater mounding was estimated using the method in U.S. Geological Survey Scientific Investigations Report 2010–5102 titled “Simulation of Groundwater Mounding Beneath Hypothetical Stormwater Infiltration Basins” (Carleton, 2010). This desktop method necessarily uses simplifying hydraulic assumptions about the unconfined aquifer, and it uses values from available hydrogeologic sources. The predicted mounds represent an order-of-magnitude estimate. The groundwater mounding analysis is diagrammed in **Figure 12-26**.

Figure 12-26: Groundwater Mounding Analysis Diagram



The results of the groundwater mounding analysis showed that the stormwater modelling runoff from the Proposed Project may have a minimal impact on the upper surface of the freshwater lenses. For the Lower Valley Freshwater Lens, the analysis results in a theoretical mound of 0.7 ft (0.21 m) at the centre of the basin. The predicted theoretical mound for the North Side Freshwater Lens was 0.8 ft (0.24 m) at the centre of the basin, although the mound would actually be smaller than 0.8 ft (0.24 m), because the theoretical mound is highest at the basin centre, and the edge of the lens is approximately 0.6 mi (0.97 km) from the Proposed Project. Both results are less than 1 ft (0.3 m), which is a relatively small temporary change.

12.4 Project Impacts

This section describes the potential impacts to hydrology and drainage that are estimated to occur as a result of the Proposed Project, either directly or indirectly through construction or operations.

The Proposed Project is described in **Chapter 6: Proposed Project – Engineering Features**. **Chapter 15: Summary of Direct, Indirect, Secondary/Induced and Cumulative Effects** includes Secondary, Induced, and Cumulative impacts.

For this specific discipline, the entire mainline corridor width of 220 ft (67 m) was used to calculate potential impacts along the mainline of the Proposed Project and a width of 41 ft (12.5 m) was used for the roadway sections that are included for the Will T Connector. The estimated LOD areas surrounding the proposed intersections and access points, as well as locations with wider needs for cut or fill slopes were also included in the impact calculations.

12.4.1 Quantitative Impact Assessment

The following assessment involves evaluation of the potential impacts caused by the Proposed Project on the following resources:

- CMW
- Mastic Reserve
- Meagre Bay Pond
- Freshwater Lenses
- Developed Areas
- Drainage Wells

Potential impacts from the Proposed Project on the identified resources may include a change of water circulation patterns, increase of stormwater runoff volume and velocity, pollution from stormwater runoff, and impact to the ecology of natural resources. Based on the storm surge model prepared by Baird and the rainfall runoff model prepared by RVE, the openings provided by the proposed structures are anticipated to prevent the roadway from impounding water at any significant depth or for any significant duration, thereby allowing the corridor to function without the negative impacts associated with "damming" storm surges or runoff. The detailed design and construction of the roadway should be developed such that storms larger than those modelled are anticipated to overtop the roadway before complete inundation of the structure openings. The detailed design should also address the placement of openings under the road, such as culverts and drainage pipes, to avoid hydrologic disconnection of wetlands and other such impacts.

Regarding stormwater management design and the construction of measures deemed necessary to manage roadway runoff, the following classification is offered. Due to the direct proximity of tidal waters, the management of peak runoff discharge rates (aka "stormwater quantity control") is not recommended for the project. Instead, in areas directly adjacent to developed areas, conveyance of storm flows will be designed using closed drainage (i.e., inlet, pipes and outlet) systems to convey runoff to stable outfalls away from private properties or adjacent, habitable structures. In naturalized areas (i.e., the open-section, ditched roadway through the CMW), stormwater management is proposed to be provided in the form of linear treatment systems such as vegetated, pre-treatment storage strips or other linear means, to filter roadway runoff and mitigate for the lack of the infiltration wells traditionally used on Grand Cayman.

Since the potential change of surface water flows/drainage patterns/flood risk and pollution impacts various resources, an overview is provided for these two general impacts and then resource-specific impacts are provided under each resource impact section. Resiliency to rainwater runoff and coastal surge is described in later parts of this section.

12.4.1.1 Change of Surface Water Flows and Drainage Patterns/ Flood Risk Overview

The Proposed Project may change surface water flows and drainage patterns and locally increase flood risk on the CMW, Mastic Reserve, Meagre Bay Pond, Freshwater Lenses and developed areas. Impacts may occur temporarily during construction by elements such as temporary storage and stockpiling of materials and during long-term operation by elements such as an increase of stormwater runoff volume and velocity from impervious surfaces (pavement). Best Management Practices can be utilised during construction to minimise these potential impacts. In addition, a potential damming or impoundment effect caused by the construction of the proposed roadway could change the baseline water circulation patterns. The hydrology could be restricted to the CMW north of the proposed roadway and cause inundation of the mangroves and adjacent developed areas south of the proposed roadway. Openings in the roadway, such as bridges and culverts, could reduce the damming and impoundment effect.

Distance, increase of impervious area, and storm modelling results were used to assess potential hydrologic and hydraulic impacts of the Proposed Project upon the applicable resource. The distance from the Proposed Project to each resource was measured. This metric was used because runoff from the Proposed Project is anticipated to contain more pollutants and have a greater hydrologic impact on a resource that is closer to the Proposed Project than one that is farther away. In addition, since impervious surfaces can increase stormwater runoff volume and velocity, the increase of impervious surface area due to the Proposed Project was analysed for each applicable resource. Hydrologic and hydraulic modelling described in **Section 12.3: Studies for the Proposed Project** was used to assess the impoundment effect of the Proposed Project.

Assessment of the Proposed Project's impacts upon the applicable resources with respect to the components previously described are provided in subsequent sections while the overall increase of impervious area for the Proposed Project is summarized in **Table 12-6**.

*Table 12-6: Increase in Impervious Area**

Scenario	Increase of Impervious Area (ac)	Increase of Impervious Area (ha)
Proposed Project	145	59

* *Includes asphalt pavement area (for travel lanes, shoulders, micromobility path) and concrete pavement area (for sidewalks, bus stops, traffic separators and median barrier)*

See **Chapter 6: Proposed Project – Engineering Features** for additional details.

12.4.1.2 Pollution Overview

The operations from the Proposed Project have the potential to release contaminants that may potentially pollute sensitive habitats and the underlying aquifers. Contaminants may consist of toxic metals, suspended solids, and hydrocarbons that can be deposited onto the road from vehicle leaks, such as crankcase oil, transmission, hydraulic and brake fluid, antifreeze and gasoline. Contaminants can be released directly (e.g., spillages) or indirectly (via surface water runoff).

For this analysis, the future year 2074 roadway surface was used to analyse the potential for contamination as well as to compare the potential pollution impacts of the Proposed Project on each resource. The future year 2074 typical roadway sections showing the dimensions of the impervious areas are included in **Section 6.1: Corridor Features and Timeline**.

The results of the hydrology and hydraulic analysis were utilised to determine the potential impact of the Proposed Project on each resource by using the movement of stormwater runoff from a rainfall event. Within the study area, stormwater runoff generally flows (1) from the west to the east and then north and (2) from the east to the west and then north (Razzaghmanesh, M., and Gause, S. (2024). The distance from the resource and the Proposed Project was measured. In addition, the increase of impervious area was compared to the total estimated drainage area of the resource based on the subwatershed areas developed during the hydrology and hydraulic analysis (see **Section 12.3: Studies for the Proposed Project**). The potential pollution impact on the CMW, Mastic Reserve, Meagre Bay Pond, Freshwater Lenses, and developed areas is included in their respective section.

12.4.1.3 Central Mangrove Wetland (CMW)

The hydraulic functions of the CMW will be affected by the Proposed Project. The potential impoundment effect of the proposed roadway within the CMW could change the baseline water circulation patterns. The hydrology could be restricted to the CMW north of the proposed roadway and cause inundation of the mangroves and adjacent developed areas south of the proposed roadway. This could result in 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, the ecological or aesthetic value of the area and may exacerbate erosion. In addition, the Proposed Project has the potential to release contaminants that may potentially pollute the CMW as previously described.

The loss of mangroves reduces transpiration, which may increase runoff and could reduce floodplain roughness, thereby potentially increasing run-off velocity and reducing protection from tropical storms and hurricanes. In addition, the removal of or drowning of mangroves may decrease precipitation on the western end of the island. Additional impacts to the CMW are described in the **Chapter 13: Terrestrial Ecology**.

<u>Hydrology, Hydraulics and Drainage Impact Assessment</u>

The potential hydrologic and hydraulic impacts and potential for pollution impacts were assessed for the CMW using the following methods:

- Removal of CMW area
- Length of proposed roadway through CMW
- Water budget
- Rainfall runoff modelling
- Surge modelling

It is assumed that the larger the removal of the CMW, the larger the potential for hydrologic/hydraulic function impacts. Therefore, the extent of such impacts to the CMW was determined by the area of CMW that would be removed. The CMW area that is anticipated to be removed for the Proposed Project is summarized in **Table 12-7**. To determine the percentage of CMW removed, the CMW removed area was divided by the total area of the CMW (8,655 ac/ 3,502 ha). Overall, the Proposed Project would result in less than 1% CMW removal.

Table 12-7: Removed CMW Area

Scenario	Area of Removed CMW (ac)	Area of Removed CMW (ha)	Total Area of CMW (ac)	Total Area of CMW (ha)	Decrease of CMW (%)
Proposed Project	76	31	8,655	3,502	0.9%

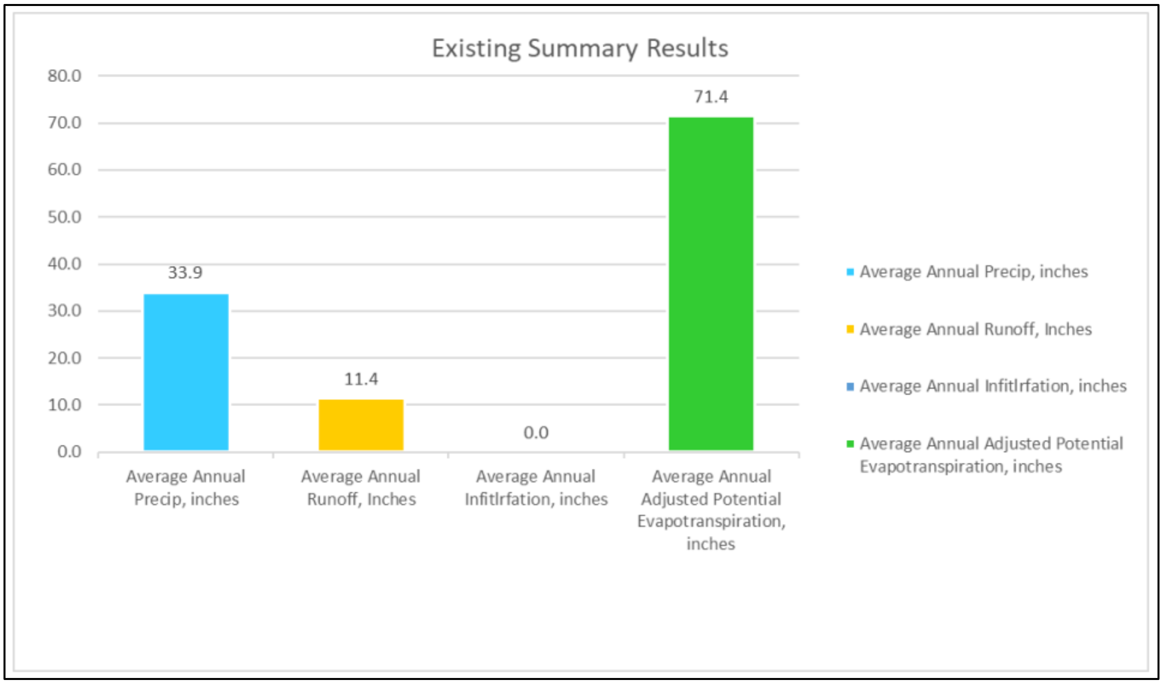
The length of the Proposed Project through the CMW was measured. This metric was used because, as the RVE and Baird modelling demonstrates, the Proposed Project causes some level of hydrologic/hydrologic impacts in the CMW and, therefore, a greater span across the CMW results in overall greater level of impacts. The length of roadway through the CMW for the Proposed Project is summarized in **Table 12-8**.

Table 12-8: Length of Roadway Through CMW

Scenario	Length of Roadway (mi)	Length of Roadway (km)
Proposed Project	2.8	4.5

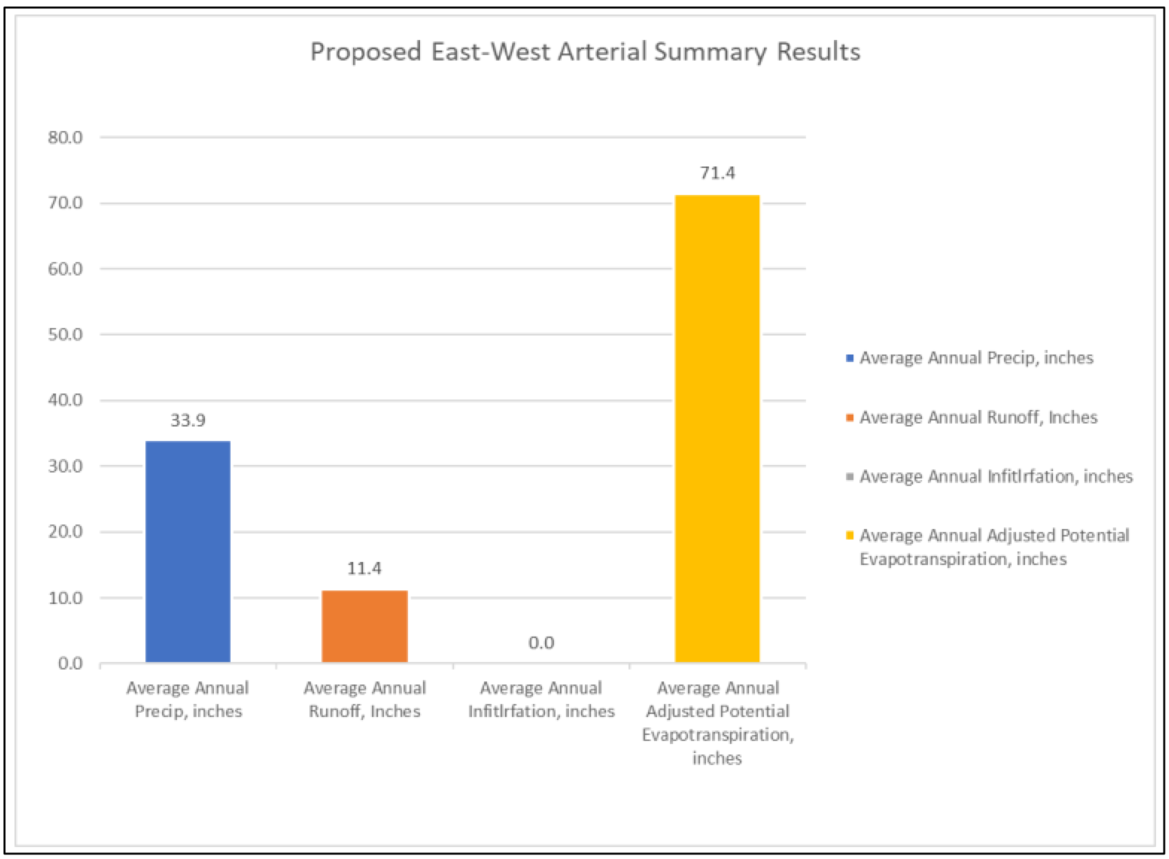
A water budget analysis, reflecting both Baseline and Proposed Project conditions, was completed for the CMW. This water budget involved evaluation of the long-term water additions, such as rainfall runoff, and subtractions, such as evapotranspiration, on the CMW as a whole in order to determine the effect that the Proposed Project would have on the natural water fluctuation in the CMW. The results indicate that the CMW pool and water level would be negligibly affected by the Proposed Project. **Figures 12-27** and **12-28** illustrate the Baseline Conditions and Proposed Project water budget, respectively, and demonstrate the negligible effects the Proposed Project has on the water budget of the CMW.

Figure 12-27: Baseline Condition Water Budget Summary Results



Source: Gause and Razzaghmanesh, 2023

Figure 12-28: Proposed Project Water Budget Summary Results



Source: Gause and Razzaghmanesh, 2023

Rainfall modelling and surge modelling were completed by RVE and Baird respectively to assess the potential drainage impact of the Proposed Project on the CMW. This modelling included the effects of the preliminary bridge opening configuration for the Proposed Project. Generally, the results for the Proposed Project showed a slight increase in CMW flood levels as compared to the Baseline Conditions where water levels will rise further than in previous floods. The increase is presumably due to the road embankment slightly limiting the floodwater's inland movement. The study also indicates that the water level in the CMW exceeds the Baseline Conditions water level for a certain length of time due to the Proposed Project. These conditions suggest that the Proposed Project modelled with the proposed openings would result in slightly higher peak water surface elevations and longer drain times for the water that is impounded.

The formation of an impoundment was assessed using two factors. The first factor is the difference in peak flood level between Baseline and Proposed Project conditions. The second factor is the length of time that the flood level with the Proposed Project is greater than the Baseline flood level by at least 0.3 ft (0.1 m). The term impoundment here refers to the difference in flooding (both height and duration) between the Proposed Project and the Baseline Conditions. These impoundment values indicate both how much higher and how much longer the flooding will persist due to the Proposed Project. These differences in flooding values include both positive (an increase in level and duration) and negative (a decrease in level and duration) values. These impoundment values were taken directly from the storm surge modelling performed by Baird, and they provide the best indication of how the floodwaters will change due to the Proposed Project. The values reported are averages of the results from the seven synthetic storms that were run in the model. The results of this analysis are summarized in **Table 12-9**.

Table 12-9: Floodwater (Including Surge and Rainfall) Impoundment Impacts on the CMW

Scenario	Average Duration of Increased Impoundment (hours)	Average Difference of Maximum Impoundment (ft/m)
Proposed Project	2	+0.2/0.07

The results show slight increases in the maximum floodwater levels and duration of flooding. Based on discussions with RVE and Baird, the slight differences in floodwaters shown for the CMW and for the other resources described in later sections are within acceptable tolerances for the scale of storms being considered. Additionally, the impoundment effects are expected to recede gradually via low flows distributed among the roadway opening structures.

<u>Pollution Impact Assessment</u>

Since baseline conditions on pollutants levels is not available, a comprehensive pollution impact assessment was not conducted due to the lack of sufficient available water quality data. Therefore, the potential pollution impact assessment focused on the increase of impervious area. Further assessment is recommended to be carried out at the detailed design stage.

Potential for pollution from the roadway was assessed based on the increase of impervious area compared to the CMW drainage area. Most of the stormwater runoff from the Proposed Project eventually travels to and through the CMW. Therefore, the entire increase in impervious area was calculated for the Proposed Project. In addition, the increase in impervious area directly adjacent to the CMW was calculated by multiplying the length of proposed roadway through the CMW and the width of the paved roadway.

The increased impervious area due to the Proposed Project is summarized in **Table 12-10**. The total increase of impervious area divided by the total drainage area of the CMW is 1.3% for the Proposed Project.

Table 12-10: Impervious Area Increase Assessment for the CMW

Scenario	Total Increase of Impervious Area (ac/ha)	Increase of Impervious Area Direct Discharge to CMW (ac/ha)	Total Drainage Area to CMW (ac/ha)	Total Increase Impervious Area/Total Drainage Area (%)
Proposed Project	145/59	42/17	11,172/4,521	1.3%

12.4.1.4 Mastic Reserve

The Mastic Reserve, which encompasses much of the Mastic Trail area, is part of a catchment area and is also valued for its role in groundwater recharge. The Proposed Project could potentially affect the hydrology and water quality of the Mastic Reserve by converting pervious groundwater recharge areas to impervious roadway surface. The Proposed Project is not located within the Mastic Reserve but is relatively close to the Mastic Reserve on the east end of the project. Additional information on the Mastic Reserve is included in **Chapter 13: Terrestrial Ecology** and **Chapter 14: Cultural and Natural Heritage**.

<u>Hydrology, Hydraulics and Drainage Impact Assessment</u>

The potential hydrologic and hydraulic impacts and potential for pollution impacts were assessed for the Mastic Reserve using the following methods:

- Distance from Mastic Reserve
- Rainfall runoff modelling
- Surge modelling

The centreline distance from the Proposed Project to the Mastic Reserve is summarized in **Table 12-11**.

Table 12-11: Distance Between the Proposed Project and the Mastic Reserve

Scenario	Distance (ft)	Distance (m)
Proposed Project	1,574	480

Rainfall modelling and surge modelling were completed by RVE and Baird, respectively, to assess the potential drainage impacts of the Proposed Project on the Mastic Reserve. Generally, the results showed a slight decrease in the peak water level due to the Proposed Project; however, the study also showed that, on average, the water in the Mastic Reserve is impounded for longer than

Baseline Conditions. These conditions suggest that, while the Proposed Project is generally not impactful when considering peak water surface elevations, the inclusion of the roadway, which would also include associated openings, would result in longer drain times for the water that is impounded. Based on discussions with RVE and Baird, the slight differences in floodwaters shown for the Mastic Reserve are within acceptable tolerances for the scale of storms being considered. Impoundment in the Mastic Reserve is measured using the same variables as were used for the CMW. The results of this analysis are summarized in **Table 12-12**.

Table 12-12: Floodwater (Including Surge and Rainfall) Impoundment Impacts on the Mastic Reserve

Scenario	Average Duration of Increased Impoundment (hours)	Average Difference of Maximum Impoundment (ft/m)
Proposed Project	1	-0.1/-0.04

The floodwater impoundment differences shown in the modelling results above are expected to affect a majority of the Mastic Reserve area. Generally, impacts on a region such as the Mastic Reserve would be similar over much of the area, although slightly greater impacts could occur close to the road or close to any large openings under the road.

Pollution Impact Assessment

The potential for pollution from the roadway was assessed based on the increase of impervious area with direct drainage to the Mastic Reserve and the distance from the centreline of the Proposed Project to the Mastic Reserve. The Mastic Reserve is relatively higher in elevation than the surrounding area and thus is less likely to be polluted from the roadway. The increase of impervious area with direct drainage to the Mastic Reserve was calculated for the Proposed Project and is summarized in **Table 12-13**. Based on this analysis, the Proposed Project would not pose a pollution concern for the Mastic Reserve since there is no increase in impervious area with direct discharge to the Mastic Reserve.

Table 12-13: Impervious Area Increase Assessment for the Mastic Reserve

Scenario	Increase of Impervious Area with Direct Drainage (ac/ha)	Distance from Alignment to Resource (ft/m)
Proposed Project	0	1,574/480

12.4.1.5 Meagre Bay Pond

The hydrology and water quality of the Meagre Bay Pond may be potentially affected by the Proposed Project. The Proposed Project is located between Meagre Bay Pond and the CMW and could potentially disconnect (hydrologically) Meagre Bay Pond from the CMW, which could limit the periodic salt flushing during heavy and prolonged rainfall events. In addition, due to the location of the new roadway in relation to Meagre Bay Pond, pollutants from the roadway could be deposited in Meagre Bay Pond during larger storms. Additional information on the Meagre Bay Pond is included in **Chapter 14: Cultural and Natural Heritage**.

Hydrology, Hydraulics and Drainage Impact Assessment

The potential hydrologic and hydraulic impacts and potential for pollution impacts were assessed for the Meagre Bay Pond using the following methods:

- Distance from Meagre Bay Pond
- Rainfall modelling
- Surge modelling

The centreline distance from the Proposed Project to the Meagre Bay Pond is included in **Table 12-14**.

Table 12-14: Distance Between the Proposed Project and the Meagre Bay Pond

Scenario	Distance (ft)	Distance (m)
Proposed Project	1,291	394

Rainfall modelling and surge modelling were completed by RVE and Baird, respectively, to assess the potential drainage impact of the Proposed Project on the Meagre Bay Pond. Overall, the results showed a slight decrease in the peak water level due to the Proposed Project (-0.4 ft/ -0.11 m). The study also showed that the average duration of increased impoundment was 8 hours. Based on discussions with RVE and Baird, the slight difference in floodwaters and the increase in duration shown for Meagre Bay Pond is within acceptable tolerances for the scale of storms being considered. The Baird report further states that areas such as Meagre Bay Pond that experience an increase in impoundment duration and decrease in maximum impoundment could be mitigated for by the adjustment of roadway opening structures. However, this would come at a trade off as decreasing the impoundment duration would likely result in higher maximum impoundment levels as well. This level of adjustment will need to be addressed in the detailed design analysis.

Impoundment in Meagre Bay Pond is measured using the same variables as were used for the CMW. The results of this analysis are summarized in **Table 12-15**.

Table 12-15: Floodwater (Including Surge and Rainfall) Impoundment Impacts to the Meagre Bay Pond

Scenario	Average Duration of Increased Impoundment (hours)	Average Difference of Maximum Impoundment (ft/m)
Proposed Project	8	-0.4/-0.11

Pollution Impact Assessment

The potential pollution impacts were assessed using the increase of impervious area with direct discharge to the Meagre Bay Pond drainage area and the distance from the centreline of the

Proposed Project to the Meagre Bay Pond. The results of this analysis are summarized in **Table 12-16**. Based on this analysis, the Proposed Project would not pose a pollution concern for Meagre Bay Pond since there is no increase in impervious area with direct discharge to Meagre Bay Pond.

Table 12-16: Increase of Impervious Area Assessment for the Meagre Bay Pond

Scenario	Increase of Impervious Area with Direct Discharge (ac/ha)	Distance from Alignment to Resource (ft/m)
Proposed Project	0	855/261

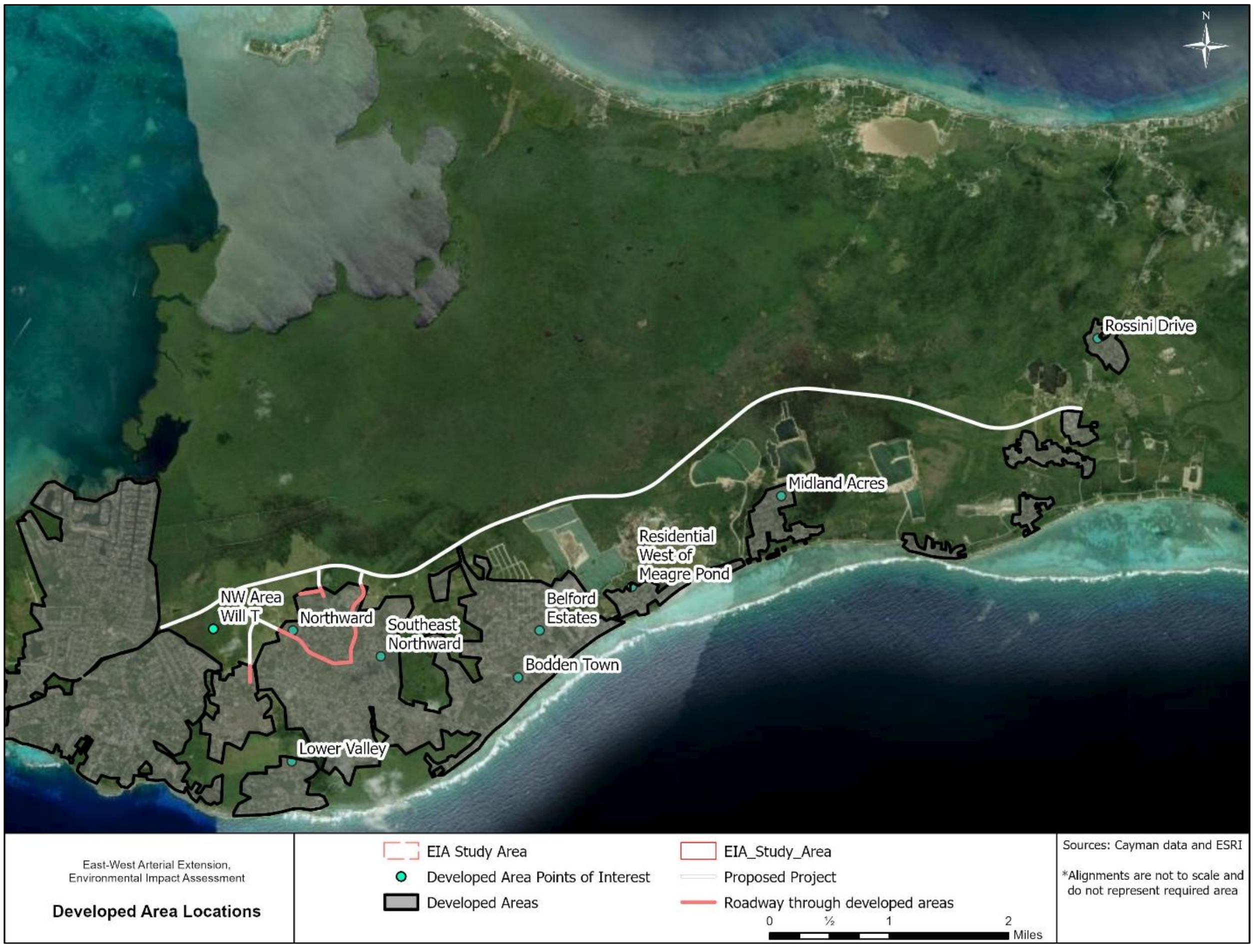
12.4.1.6 Freshwater Lenses

As demonstrated and stated in **Section 12.3.7: Groundwater Mounding Analysis**, the impact of the Proposed Project on the Freshwater Lenses is anticipated to produce a negligible effect on these resources. Detailed information regarding the Freshwater Lenses can be found in **Chapter 11: Geo-Environmental**.

12.4.1.7 Developed Areas

The developed areas within the study area include existing residential, business, and commercial areas of Northward, Lower Valley, Bodden Town, the Northwest Areas of the proposed Will T Connector, Southeast Northward, Belford Estates, Midland Acres, Rossini Drive, Savannah Gully, and the residential developments west of Meagre Bay Pond, and along Frank Sound Road. There are also numerous additional developed areas along the existing Bodden Town Road corridor throughout the study area. The potential hydrology, hydraulics and drainage and pollution impacts on these developed areas were assessed for the Proposed Project. The developed areas assessed as part of the Baird modelling analysis are shown in **Figure 12-29**.

Figure 12-29: Developed Area Locations as part of the Baird Surge Modelling



Hydrology, Hydraulics and Drainage Impact Assessment

For this analysis, it was assumed that the longer the roadway distance through the developed areas, the more potential of the roadway to cause the impoundment of floodwaters through these areas; therefore, the impact of the Proposed Project on these developed areas was assessed by the length of roadway within the developed areas. The results of this analysis are summarized in **Table 12-17**.

Table 12-17: Length of Additional Roadway Through Developed Areas

Scenario	Additional Length of Roadway (mi)	Additional Length of Roadway (km)
Proposed Project	1.9	3

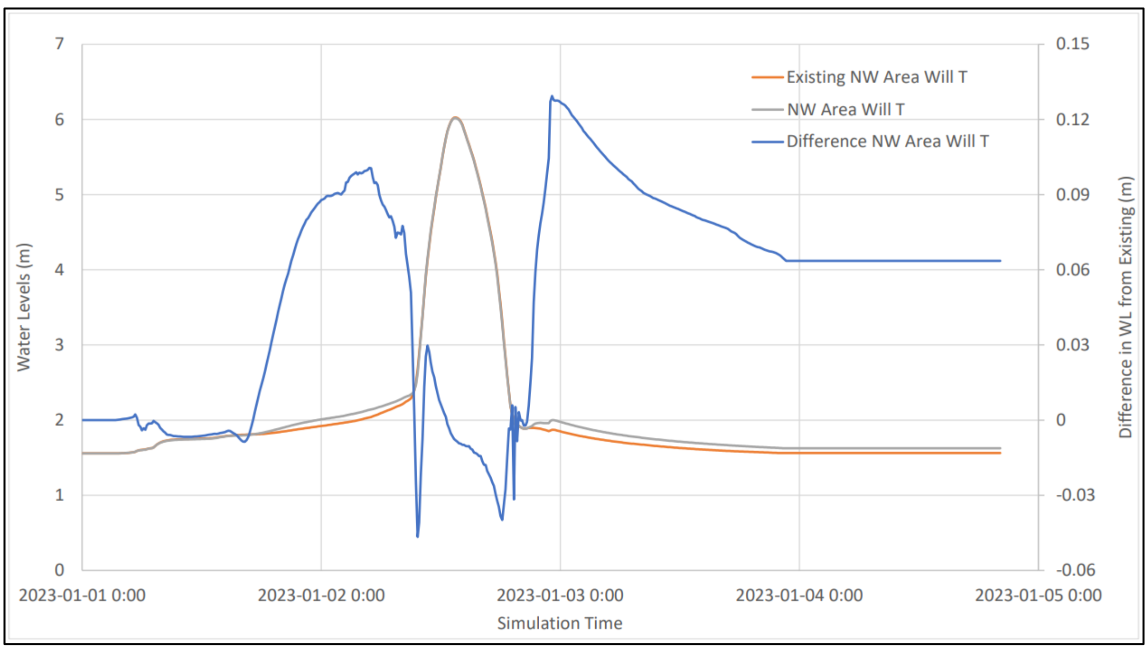
Rainfall modelling and surge modelling were completed by RVE and Baird, respectively, to assess the potential drainage impact of the Proposed Project on the developed areas. Overall, the results from the Baird modelling in **Table 12-18** showed a slight decrease in the peak water level due to the Proposed Project. The study also showed that the average duration of increased impoundment in the developed areas ranged from 0 to 10 hours.

Table 12-18: Floodwater (Including Surge and Rainfall) Impoundment Impacts to Developed Areas

Location	Average Duration of Increased Impoundment (hours)	Average Difference of Maximum Impoundment (ft/m)
NW Area Will T	10	0/-0.01
Lower Valley	0	-0.2/-0.07
Northward	0	0/-0.01
Southeast Northward	0	-0.1/-0.02
Bodden Town	0	-0.1/-0.03
Belford Estates	1	-0.2/-0.06
Midland Acres	0	-0.1/-0.03
Rossini Drive	6	-0.1/-0.04

The results showed longer flood durations at NW Area Will T and Rossini Drive, but these are attributed to slight local differences in shallow drainage, rather than any broad impoundment of water in the area due to the Proposed Project. An example of this local shallow drainage effect for a specific location along the Will T area is shown in **Figure 12-30**.

Figure 12-30: Example of Ponding Issue in Shallow Regions



Sourced from: Baird and Associates, 2024

Figure 12-30 shows the baseline modelling results versus the proposed results for a specific location in the Will T area. The orange line in the figure represents the baseline model water levels and the grey line represents the proposed model water levels in metres and referenced to the y axis on the left side of the graph. The blue line represents the difference between the baseline and proposed water levels in metres with an exaggerated scale and referenced to the y axis on the right side of the graph. The results show the water levels in the proposed condition flattening out at an elevation higher than the baseline results for an extended length of time due to localized puddling effects in the modelling (Baird and Associates, 2024). The Baird report stated that the modelling showed an elevation difference between the Baseline and Proposed Project conditions for days after the peak of the event due to differences in how the mesh represents the topography, and the inability of one of the mesh systems (either the Baseline or Proposed Project) to drain a puddle (Baird and Associates, 2024). This modelling limitation gives rise to some of the longer average duration of increased impoundment results.

As previously described for other resources areas, the results of this analysis show that there would be a slight decrease in the peak water level due to the Proposed Project; however, the study also showed that, on average, the water in the identified developed areas is impounded for longer than Baseline Conditions. These conditions suggest that, while the Proposed Project is generally not impactful when considering peak water surface elevations, the configuration of the roadway and the associated openings would result in longer drain times for the water that is impounded. Based on discussions with RVE and Baird, the slight differences in floodwaters shown for the developed areas are within acceptable tolerances for the scale of storms being considered.

The amount of potential impoundment in the developed areas was measured using the same variables that were used for the CMW analysis. The results of this analysis are reported for the individual areas covered by this study in **Table 12-18** above. The values were also averaged, and the results are summarized in **Table 12-19**.

Table 12-19: Floodwater (Including Surge and Rainfall) Impoundment Impacts to Developed Areas

Scenario	Average Duration of Increased Impoundment (hours)	Average Difference of Maximum Impoundment (ft/m)
Proposed Project	2	-0.1/-0.03

Pollution Impact Assessment

Since baseline pollutants level data is not available, a comprehensive pollution impact assessment was not conducted due to the lack of sufficient available water quality data. Therefore, the potential pollution impact assessment focused on the increase of impervious area. Further assessment is recommended to be carried out at the detailed design stage.

To assess potential pollution impacts for the developed areas, the increase of impervious area along the Will T Connector was used for the Proposed Project. Due to the lack of development along the remainder of the Proposed Project, these surface areas were not included in this analysis. The length of the roadway through developed areas (listed in **Table 12-17**) was multiplied by the proposed impervious area to provide the increase in impervious area through the Will T Connector area. The summary of the pollution potential assessment is included in **Table 12-20**.

Table 12-20: Increase of Impervious Area Assessment for Developed Areas

Scenario	Increase of Impervious Area (ac/ha)	Distance from Alignment to Developed Areas (mi/km)
Proposed Project	9/4	0/0

12.4.1.8 Damage to Existing Drainage Infrastructure

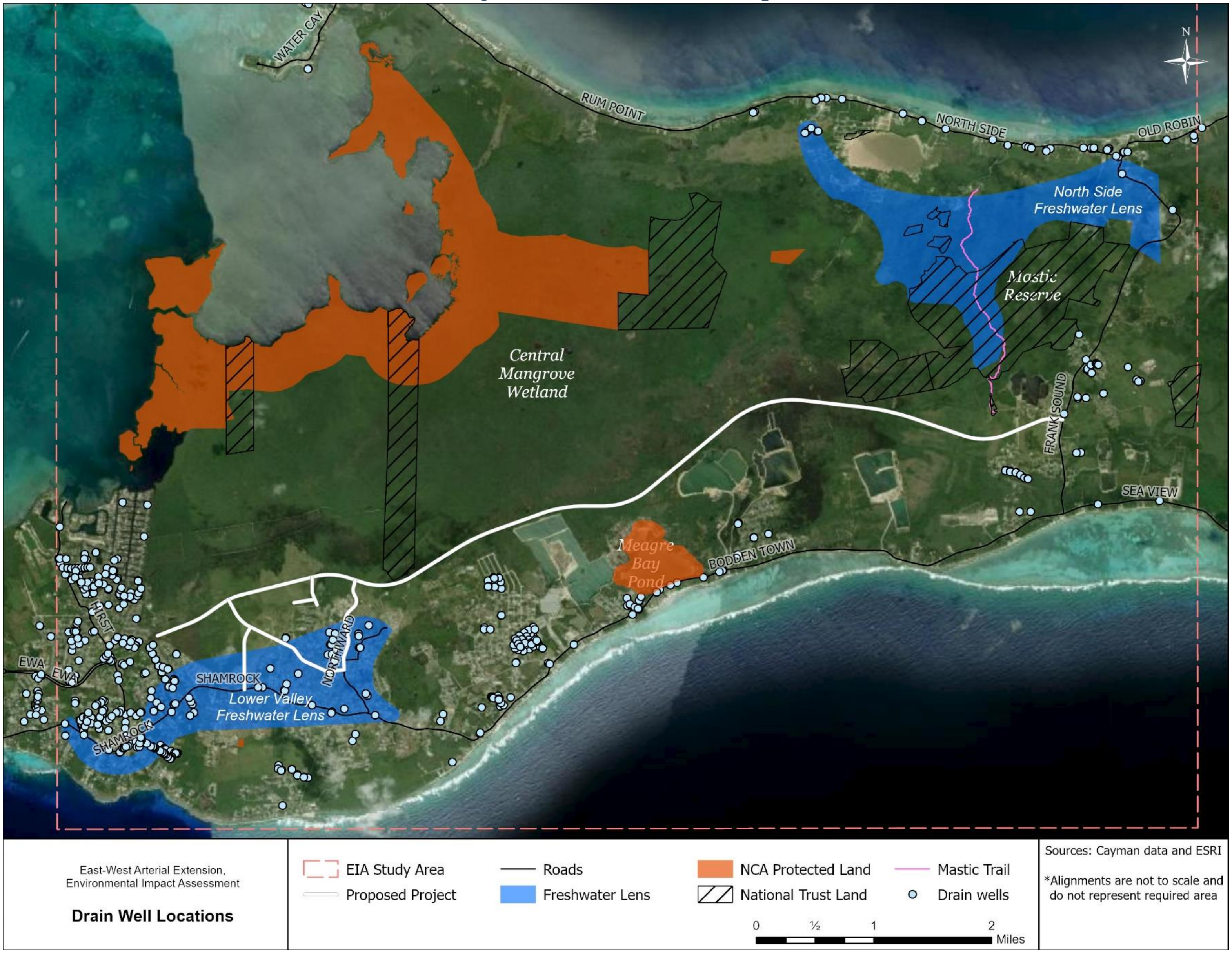
Construction of the Proposed Project may inadvertently cause damage to existing drainage infrastructure and result in flooding of neighbouring properties or infrastructure. A map of existing drain wells was developed using data provided by the NRA and is shown in **Figure 12-31.**

Drain wells are one of the main drainage features used on Grand Cayman. There is one drainage well along the Proposed Project, located at the east end of the project near Frank Sound Road, which could potentially be affected by construction activities and is summarized in **Table 12-21**. Overall, the small number of wells affected by the Proposed Project and the anticipated inclusion of drainage systems as part of the detailed design, results in this impact not having a significant effect.

Table 12-21: Potentially Affected Drainage Wells

Scenario	Potentially Affected Drainage Wells (Each)
Proposed Project	1

Figure 12-31: Drain Well Map



12.4.2 Qualitative Impact Assessment

A qualitative impact assessment was performed for the Baseline Conditions and Proposed Project to identify the significance of the potential effects. The assessment included three steps, including (1) rating the importance of water features, (2) determining the magnitude of impact, and (3) identifying the overall assessment score. Methodology is described in **Section 12.1: Assessment Methodology** and **Appendix E – Shortlist [Alternatives] Evaluation: Attachment H – Hydrology & Drainage – Assessment of Alternatives**. The results of the qualitative assessment are described in the following subsections.

12.4.2.1 Importance of Water Environment Features

The importance of each water feature was rated for the Qualitative Impact Assessment. Potential ratings included Low, Medium, High and Very High.

Central Mangrove Wetland: As the only large mangrove forest on Grand Cayman, the CMW is a unique national site with significant complexity and limited potential for substitution. Therefore, it receives a **"Very High"** rating on the Importance of Water Environment Features scale.

Mastic Reserve: The Mastic Reserve is a unique national site with significant complexity and limited potential for substitution. Therefore, it receives a **"Very High"** rating on the Importance of Water Environment Features scale.

Meagre Bay Pond: The Meagre Bay Pond is a unique national site with significant complexity and limited potential for substitution. Therefore, it receives a **"Very High"** rating on the Importance of Water Environment Features scale.

Freshwater Lenses: The Freshwater Lenses are unique national sites with significant complexity and limited potential for substitution. Therefore, they receive a **"Very High"** rating on the Importance of Water Environment Features scale. Detailed information regarding the Freshwater Lenses can be found in **Chapter 11: Geo-Environmental**.

Developed Areas: Although not specifically a water environment feature, developed areas may potentially be hydraulically impacted by the proposed roadway and therefore, they were also included in this analysis. Bodden Town is an important residential and commercial centre on Grand Cayman, along with the rest of the developed areas listed in **Section 12.4.1.7: Developed Areas**. Therefore, developed areas receive a **"Very High"** rating on the Importance of Water Environment Features scale.

Existing Drainage Infrastructure: Existing man-made drainage infrastructure is an important feature to convey stormwater and to minimise flooding. Since this is a man-made feature, it is anticipated that any drainage infrastructure affected by the construction would be replaced; therefore, it receives a **"Low"** rating on the Importance of Water Environment Features scale.

12.4.2.2 Magnitude of Impact

The magnitude of the Proposed Project impact was determined for each water feature by estimating the potential extent of the effect due to the proposed roadway. Potential ratings included Negative, Negligible, and Positive. Negative and Positive impacts were further categorized as Major, Moderate, and Minor.

Central Mangrove Wetland: The Proposed Project is anticipated to directly impact 76 ac (31 ha) of the CMW, which is less than 1% of the total CMW area (8,655 ac). Although approximately 2.8 mi (4.5 km) of the Proposed Project travel through the CMW, rainfall and surge modelling results show minimal impact to the CMW drainage patterns, flooding, and impoundment durations. The water budget modelling of the CMW showed that the CMW pool and water level would not be affected by the proposed roadway. In addition, pollution from the Proposed Project is anticipated to be limited based on the relatively small percentage increase of impervious area compared to the total drainage area of the CMW (approximately 1%). The temporary impacts during construction, including change of surface water drainage patterns and localized flood risk, pollution, and soil erosion and compaction, can be minimised using best management practices. While there is anticipated to be a measurable change in the feature, it would be of limited size and/or proportion, and therefore, the Proposed Project received a **"Minor Negative"** rating on the Magnitude of Potential Impacts scale.

Mastic Reserve: Based on the rainfall and surge modelling, it is anticipated that the Proposed Project would minimally impact the drainage patterns of the Mastic Reserve. In addition, pollution from the Proposed Project is anticipated to be limited based on the stormwater run-off flow pattern, higher ground elevation, and the distance of the Proposed Project from the Mastic Reserve (1,574 ft/ 480 m). Construction impacts would be limited due to the distance between the roadway and the Mastic Reserve and the higher ground elevation of the Mastic Reserve when compared to the proposed roadway. Based on the rainfall and surge modelling, the baseline drainage patterns, and distance between the roadway and Mastic Reserve, it is anticipated that the Proposed Project would have a minimal impact on the Mastic Reserve; therefore, the Proposed Project received a **"Minor Negative"** rating on the Magnitude of Potential Impacts scale.

Meagre Bay Pond: Based on the rainfall and surge modelling, it is anticipated that the Proposed Project would minimally impact the drainage patterns of the Meagre Bay Pond. In addition, pollution from the Proposed Project is anticipated to be limited based on the stormwater run-off flow pattern and the distance of the Proposed Project from the Meagre Bay Pond (1,291 ft/ 394 m). The temporary impacts during construction, including change of surface water drainage patterns and localized flood risk, pollution, and soil erosion and compaction, can be minimised using best management practices. Based on the rainfall and surge modelling, the baseline drainage patterns, and distance between the roadway and Meagre Bay Pond, it is anticipated that the Proposed Project would have minimal impact on Meagre Bay Pond; therefore, the Proposed Project received a **"Negligible"** rating on the Magnitude of Potential Impacts scale.

Freshwater Lenses: As demonstrated in the above groundwater mounding assessments, the theoretical mounds (rise in the water table) at the lenses are less than 1 ft (0.3 m) at the centre of the basin for the Lower Valley Freshwater Lens and North Side Freshwater Lens. These impacts are anticipated to be temporary in nature and minimally impact the upper surface of the Freshwater Lenses. The temporary impacts during construction, including change of surface water drainage patterns and localized flood risk, pollution, and soil erosion and compaction, can be minimised using best management practices. Therefore, the Proposed Project received a **"Negligible"** rating on the Magnitude of Potential Impacts scale.

Developed Areas: Although the Proposed Project travels 1.9 mi (3.0 km) through the developed areas, based on the rainfall and surge modelling, it is anticipated that the Proposed Project would minimally impact the drainage patterns and flooding of the developed areas. In addition, pollution from the Proposed Project is anticipated to occur based on the stormwater run-off flow pattern and the increase of impervious area directly adjacent to the developed area (28 ac/ 11 ha). The temporary impacts during construction, including change of surface water drainage patterns and localized flood risk, pollution, and soil erosion and compaction, can be minimised using best management practices. Based on the rainfall and surge modelling, the existing drainage patterns, and impervious area increase, it is anticipated that the Proposed Project would have minimal impact on developed areas; therefore, it received a **"Minor Negative"** rating on the Magnitude of Potential Impacts scale.

Existing Drainage Infrastructure: The Proposed Project is anticipated to directly impact one drainage well. Based on the wide distribution of this resource and insufficient magnitude of impact, it received a **"Negligible"** rating on the Importance of Water Environment Features scale.

12.4.2.3 Overall Assessment Score

The overall assessment score was developed by combining the ratings for the importance of water environment features and the anticipated magnitude of impact into an Overall Qualitative Rating for the Proposed Project. A summary of the anticipated magnitude of impact for the Proposed Project, along with the importance of each identified feature, is shown in **Table 12-22** and the overall assessment score is in **Table 12-23**.

The overall assessment score for the Proposed Project was **"Moderate Adverse"** for the CMW, Mastic Reserve, and Developed Areas; **"Slight Adverse"** for the Meagre Bay Pond and the Freshwater Lenses; and **"Neutral"** for the existing drainage infrastructure. The overall qualitative assessment score was **"Moderate Adverse"** for the Proposed Project.

Table 12-22: Summary Table of Importance of Water Environment Features and Magnitude of Impact

Feature	Importance of Water Environment Features	Anticipated Magnitude of Impact from Proposed Project
CMW	Very High	Minor Negative
Mastic Reserve	Very High	Minor Negative
Meagre Bay Pond	Very High	Negligible
Freshwater Lenses	Very High	Negligible
Developed Areas	Very High	Minor Negative
Existing Drainage Infrastructure	Low	Negligible

Table 12-23: Overall Assessment Score

Water Environment Feature	Proposed Project
Central Mangrove Wetland	Moderate Adverse
Mastic Reserve	Moderate Adverse
Meagre Bay Pond	Slight Adverse
Freshwater Lenses	Slight Adverse
Developed Areas	Moderate Adverse
Existing Drainage Infrastructure	Neutral
Overall Qualitative Rating	**Moderate Adverse**

12.4.3 Potential Construction and Operation Impacts

Potential impacts during the construction and operation phases of the project were further assessed by various attributes/variables to determine the magnitude of impact, importance/sensitivity of the resource, and impact significance. Construction phase impacts are included in **Table 12-24** and operation phase impacts are included in **Table 12-25.** Additional impacts to the CMW, Mastic Reserve, and Meagre Bay are described in **Chapter 13: Terrestrial Ecology** and **Chapter 14: Cultural and Natural Heritage**.

12.4.3.1 Construction Phase

Potential construction phase impacts were assessed, including the following:

- change of surface water drainage patterns and locally increased flood risk
- water, soil, and habitat pollution from construction equipment
- surface water and habitat pollution from stormwater runoff with eroded soil
- soil compaction
- flood events that may endanger site infrastructure and staff safety

Temporary storage, stockpiling of materials, and construction phases may change surface water drainage patterns and locally increase flood risk. This has the potential to occur as the roadway is progressively constructed, and stockpiles of material, such as soil and aggregate, are placed in advance of the roadway's construction. These piles of material can impede the surface water flows that would occur in an un-disturbed condition.

Construction equipment may release contaminants that pollute surface waters, sensitive habitats, and the underlying aquifers. This equipment is a necessary part of the roadway construction and usually consists of diesel engines. These engines have the potential to leak harmful products during their use and storage on the project site.

Stormwater runoff with eroded soil may pollute surface waters and sensitive habitats. As the roadbed is constructed, there will be periods with loose and compacted, bare soil exposed to the elements. As rain falls over the construction site, this soil has the potential to wash away from the construction site and into sensitive habitat and surface waters downstream of the construction area.

Construction equipment could cause soil compaction, which may result in reduced infiltration and, accordingly, increased runoff. As the heavy equipment used in the construction of the road drives over the in-situ site soils, these soils will be compressed. This increase in soil compaction will reduce the ability of the soils to infiltrate rainwater, which will lead to reduced flow to the freshwater lenses in these areas and increased runoff from these areas. There is the potential for residual effects adjacent to the road as construction vehicles travel along the length of the project.

Rainfall runoff, extreme weather, and climate change induced flood events may inundate the construction site. The construction site will require the movement of people, machinery, and materials into lower lying lands that could be vulnerable to flooding concerns. In the case of extreme weather, there is the potential for flooding to pose a risk to the workers on site as well as to the materials and equipment being used on the site.

The potential impacts have a medium to high likelihood of occurrence with a medium to high certainty. These potential impacts are adverse and local and are typically short-term, except for soil compaction, which is long-term. Potential impacts range from very low to medium in magnitude, medium to high in sensitivity, and moderate to major in significance. Potential construction phase impacts are summarized in **Table 12-24**.

Table 12-24: Potential Construction Phase Impacts on Hydrology and Drainage Resources

Receptor / Resource / Impact Summary	Description / Potential Effect (*include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude of Impact	Importance/ Sensitivity*	Significance
CMW, Meagre Bay Pond, Freshwater Lenses, Developed Areas/ Hydrology, drainage and flooding	Temporary storage, stockpiling of materials and construction phases may change surface water drainage patterns and locally increase flood risk; This effect has a high likelihood of occurrence and has been identified with a high certainty	Adverse, Short-Term, Local	Intermediate Negative	Medium	Moderate Adverse
CMW, Meagre Bay Pond, Freshwater Lenses, Developed Areas/ Pollution	Construction equipment may release contaminants that pollute surface waters, sensitive habitats and the underlying aquifers; This effect has a medium likelihood of occurrence and has been identified with a medium certainty	Adverse, Short-Term, Local	Minor Negative	High	Moderate Adverse
CMW, Meagre Bay Pond, Developed Areas/Erosion and Runoff	Stormwater runoff with eroded soil may pollute surface waters and sensitive habitats; This effect has a medium likelihood of occurrence and has been identified with a medium certainty	Adverse, Short-Term, Local	Intermediate Negative	High	Major Adverse
CMW, Meagre Bay Pond, Freshwater Lenses, Developed Areas/Soil Compaction	Construction equipment may cause soil compaction, which may result in reduced infiltration and increased runoff; This effect has a high likelihood of occurrence and has been identified with a high certainty	Adverse, Long-Term, Local	Minor Negative	Medium	Slight Adverse
Site Infrastructure and Staff Safety	Rainfall runoff, extreme weather and climate change induced flood events may inundate the construction site; This effect has a medium likelihood of occurrence and has been identified with a medium certainty	Adverse, Short-Term, Local	Intermediate Negative	Medium	Moderate Adverse

12.4.3.2 Operation Phase

Potential operation phase impacts were assessed and may include the following:

- change of surface water drainage patterns and regionally increased flood risk
- water, soil, and habitat pollution from vehicles
- increase of stormwater runoff volume and velocity which may increase erosion and flooding in areas adjacent to the road
- impact the hydrology of natural resources including alteration of water flow, water levels and surface drainage
- impact the ecology of natural resources including alteration of salinity levels, nutrient balance, oxygen concentration and temperature
- the loss of mangroves within the site footprint

Roadway layout and opening configuration may change surface water and extreme weather drainage patterns as well as regionally change flood risk. This impact is thoroughly described in previous sections. The proposed roadway generally has the potential to impede natural flow paths and cause an increase in flooding in areas upstream and/or downstream of the roadway.

Vehicles on the proposed road may release contaminants that pollute surface waters, sensitive habitats, and the underlying aquifers. As with the construction equipment, the majority of vehicles traversing the finished roadway will be gasoline automobiles. These vehicles have the potential to leak harmful fluids such as gasoline and antifreeze and other harmful debris onto the roadway. These hazardous materials have the potential to then wash off the roadway during a rainfall event and flow down into areas adjacent to the road. For the portions of the road adjacent to or upstream of sensitive locations, this can lead to a reduction in the water quality of these areas and other such ecological concerns.

The increase of stormwater runoff volume and velocity may increase erosion and flooding in areas adjacent to the road. Because the roadway surface is impervious (i.e., pavement), any areas that were pervious (i.e., vegetation and soil) in the Baseline Conditions and, accordingly had rainfall infiltration, will now produce increased rainfall runoff. The net effect of this is an increase of water flowing from the site during rainfall events. This can lead to erosion concerns along the roadside slopes and at drainage system outfall points. There is also the concern of water that used to flow freely now being channelized through roadway opening structures during larger flooding events. This concentration of the water has the potential to result in increased flow velocity which can also result in erosion issues.

Impacts on the hydrology of natural resources include alteration of water flow, water levels, and surface drainage, which may be harmful to the CMW, Mastic Reserve and Meagre Bay Pond. Similar to the flooding concerns, the construction of the roadway has the potential to alter the natural flow paths along the roadway alignment. This roadway traverses delicate habitat with important baseline flow patterns, such as the natural flushing of the Meagre Bay Pond into the CMW and the fresh/salt water hydrologic gradients in the CMW. The roadway has the potential to alter these flow patterns and cause impacts to the natural resources that they serve.

The impact on the ecology of natural resources includes alteration of salinity levels, nutrient balance, oxygen concentration, and temperature that may be harmful to mangroves, wildlife, and other ecological resources. This impact is very similar to the above impact but focuses more on the ecological effects that altering the flow patterns could create. The careful balance of salinity levels, oxygen concentration, temperature and other factors plays a significant role in the health of the island's ecosystems. Any alteration to the flow patterns that help to regulate these processes can also have a negative effect on the ecosystems themselves.

The loss of mangroves in the site footprint reduces transpiration, may decrease precipitation on the western end of the island, may increase runoff and could reduce floodplain roughness, which in turn could increase run-off velocity and reduce protection from tropical storms and hurricanes. The portion of the roadway that traverses the CMW will result in some loss of mangroves, as described in previous sections. This loss of mangroves can lead to the effects mentioned above. In addition, if the roadway cuts off flow to any isolated mangrove areas, this can result in impacts to and potential loss of additional mangrove areas.

The potential impacts have a medium to high likelihood of occurrence with a medium to high certainty. These potential impacts are adverse and long-term and are typically regional, except for the increase of stormwater runoff volume and velocity, which is local. Potential impacts range from low to high in magnitude, medium to high in sensitivity, and moderate to major in significance. Potential operation phase impacts are summarized in **Table 12-25**.

Table 12-25: Potential Operation Phase Impacts on Hydrology and Drainage Resources

Receptor / Resource / Impact Summary	Description / Potential Effect (*include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude	Sensitivity	Significance
CMW, Meagre Bay Pond, Mastic Reserve, Developed Areas/Hydrology and Drainage	Roadway layout and opening configuration may change surface water and extreme weather drainage patterns and regionally change flood risk; This effect has a medium likelihood of occurrence and has been identified with a medium certainty	Adverse, Long-Term, Regional	Intermediate Negative	Medium	Moderate Adverse
CMW, Meagre Bay Pond, Freshwater Lenses, Developed Areas/Pollution	Vehicles on the proposed road may release contaminants that runoff and pollute surface waters, sensitive habitats and the underlying aquifers; This effect has a high likelihood of occurrence and has been identified with a medium certainty	Adverse, Long-Term, Regional	Minor Negative	High	Moderate Adverse

Receptor / Resource / Impact Summary	Description / Potential Effect (*include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude	Sensitivity	Significance
CMW, Meagre Bay Pond, Developed Areas/Erosion and Runoff	Increase of stormwater runoff volume and velocity which may increase erosion and flooding in areas adjacent to the road; This effect has a high likelihood of occurrence and has been identified with a high certainty	Adverse, Long-Term, Local	Minor Negative	High	Moderate Adverse
CMW, Meagre Bay Pond, Freshwater Lenses, Mastic Reserve/Natural Resource Hydrology	Impact on the hydrology of natural resources including alteration of water flow, water levels and surface drainage that may be harmful to the CMW, Mastic Reserve and Meagre Bay Pond; This effect has a medium likelihood of occurrence and has been identified with a medium certainty	Adverse, Long-Term, Regional	Major Negative	High	Large Adverse
CMW, Meagre Bay Pond, Mastic Reserve/Natural Resource Ecology	Impact on the ecology of natural resources including alteration of salinity levels, nutrient balance, oxygen concentration and temperature that may be harmful to mangroves, wildlife and other ecological resources; This effect has a medium likelihood of occurrence and has been identified with a medium certainty	Adverse, Long-Term, Regional	Major Negative	High	Large Adverse
CMW, Meagre Bay Pond, Freshwater Lenses, Developed Areas/Mangrove Loss	The loss of mangroves in the site footprint reduces transpiration, may decrease precipitation on the western end of the island, may increase runoff and could reduce floodplain roughness, which in turn could increase run-off velocity and reduce protection from tropical storms and hurricanes; This effect has a high likelihood of occurrence and has been identified with a medium certainty	Adverse, Long-Term, Regional	Minor Negative	High	Moderate Adverse

12.5 Mitigation Measure Considerations

The following subsections describe potential mitigation considerations to mitigate the impacts described for the identified hydrology and drainage elements. **Table 12-26** describes the characterisations used to evaluate the impacts and mitigation measure considerations.

Table 12-26: Impact Analysis Factors

Characterisation	Description	Quantitative Measure or Definition of Qualitative Categories
Magnitude	The size or degree of the effects compared against Baseline Conditions or reference levels, and other applicable measurement parameters (i.e., standards, guidelines, objectives)	**Negligible (N) |** Differing from the average Baseline Conditions to a very small degree but within the range of the natural variation **Very Low (VL) |** Differing from the average Baseline Conditions to a small degree but very minimally out of the range of the natural variation **Low (L) |** Differing from the average baseline and outside the range of natural variation but less than or equal to appropriate guideline or threshold value **Medium (M) |** Differing from the average baseline and outside the range of natural variation and marginally exceeding a guideline or threshold value **High (H) |** Differing from the average baseline and outside the range of natural variation and exceeding a guideline or threshold value
Geographic Extent	The geographic area over which the effects are likely to be measurable	**Limits of Disturbance (LOD) |** Occurs within the Proposed Project LOD **Outside Limits of Disturbance (OLOD) |** Occurs outside of the Proposed Project LOD, but within the identified Study Area
Timing	Considers when the environmental effect is expected to occur. Timing considerations are noted in the evaluation of the environmental effect, where applicable or relevant.	**Not Applicable (NA) |** Seasonal variations are not likely to change the effect **Applicable (A) |** Seasonal aspects may affect the outcome of the effect
Duration	The time period over which the effects are likely to last	**Short-Term (ST) |** The effect is reversible at the end of construction works **Medium-Term (MT) |** The effect is reversible within a defined length of time **Long-Term (LT) |** The effect is reversible over an extended length of time
Frequency	The rate of recurrence of the effects (or conditions causing the effect)	**Once (O) |** Effects occur once **Occasional (Oc) |** Effects that could occur randomly throughout the project lifetime **Regular (R) |** Effects can occur at regular intervals through construction and/or operation

Characterisation	Description	Quantitative Measure or Definition of Qualitative Categories
		Continuous (C) | Effects are continuous throughout construction and operation
Reversibility	The degree to which the effects can or will be reversed (typically measured by the time it will take to restore the environmental attribute or feature)	**Reversible (R) |** The Baseline Conditions will recover to their standard after the construction works are completed **Partially Reversible (PR) |** Mitigation can return the Baseline Conditions **Not Reversible (NR) |** Mitigation cannot guarantee a return to Baseline Conditions

12.5.1 Construction Phase

During construction, a number of measures should be taken to potentially prevent and/or reduce impacts on and off-site. The following section describes potential mitigation considerations to address the impacts to the identified hydrology and drainage elements during the construction phase. **Table 12-27** summarizes the potential impacts and mitigation considerations. Additional mitigation considerations for the CMW, Mastic Reserve, and Meagre Bay Pond are described in **Chapter 13: Terrestrial Ecology** and **Chapter 14: Cultural and Natural Heritage**.

Hydrology, Drainage and Flooding

During the construction phase of the project, hydrology could be impacted by stockpiling of materials and other construction related activities. This could affect the hydrology of both onsite and offsite areas including the CMW, Meagre Bay Pond, the freshwater lenses and developed areas. To assist in minimising and mitigating for these potential construction impacts, several strategies are recommended.

Potential staging/stockpile locations need to be determined and coordinated during the detailed design phase with the minimisation of impacts to the baseline drainage patterns prioritized. Project notes to be included in the detailed design will need to emphasize the need to best avoid placing stockpiles in sensitive areas, such as the identified mangroves and peat locations.

It is also recommended that additional temporary construction access and drainage systems be considered and developed by the engineer responsible for the future detailed design following FDOT's temporary construction standards along with other applicable recommendations, such as those contained within the FDOT Drainage Manual and any other similar standards and guidelines. The use of FDOT or any other recommended standards and guidelines should be confirmed by the governing authorities on Grand Cayman before their implementation. The discussion pertaining to the recommended standards has been initiated as part of this ES analysis but will need to be fully verified before and during detailed design. Where deemed feasible by the detailed design engineer, proposed drainage features (e.g., culverts) may be constructed as part of the early works process to assist in the maintenance of drainage patterns during construction, thereby minimising potential hydrologic impacts.

Additional survey, field investigation and detailed design (augmented by the collection of geotechnical data as applicable and feasible) are required to verify drainage patterns, develop staging/stockpile locations, determine/design temporary construction access/drainage plans and (where feasible) integrate with proposed drainage systems.

Pollution

As part of the construction process, numerous types of construction equipment will be present on the site and will have the potential to release contaminants that pollute surface waters, sensitive habitats, and the underlying aquifers. This pollution has the potential to affect both onsite and offsite areas including the CMW, Meagre Bay Pond, the freshwater lenses and developed areas. To assist in minimising and mitigating for this potential impact, several strategies are recommended.

Construction equipment should be stored, re-fuelled, regularly inspected, and maintained in equipment maintenance yards that are located away from identified sensitive natural resource features and are included on the detailed design plans. A Spill Emergency and Response Plan should also be developed for the Proposed Project. Additional guidance for construction site pollution prevention can be found, as an example, in State of Florida standards including the FDOT Standard Specifications, the FDOT Construction Project Administration Manual, the State of Florida Erosion and Sediment Control Designer and Reviewer Manual, and the Florida Water Management Districts Environmental Resource Permit Applicant's Handbook Volume 1. In addition to these FDOT standards, other standards define construction pollution control methods which can be applicable to the project. Therefore, the use of specific standards will be at the discretion of the team completing the detailed design, outside of this EIA. If deemed feasible based upon the detailed design and procurement method (e.g., design-build), integration of water quality protection methods into a consolidated Stormwater Pollution Prevention Plan (SWPPP) may be advisable.

Additional survey, geotechnical data, and detailed design/construction method development are required to identify appropriate maintenance and storage locations and to develop a Spill Emergency and Response Plan and/or a SWPPP.

Erosion and Runoff

The construction activities for the Proposed Project are anticipated to disturb soils on the construction site, which have the potential to generate sediment-laden flow offsite during a rainfall event, thereby potentially polluting downstream surface waters and sensitive habitat. This offsite flow could potentially affect the CMW, Meagre Bay Pond and developed areas. The following are several mitigation measures that could potentially reduce this type of impact.

Vegetation clearing should be limited to active construction areas, and the disturbed areas should be stabilized as soon as possible after the work has been completed. It is recommended that disturbed areas, which will not be subject to active construction, should not be left unstabilised for more than seven days. Any active construction areas should also be protected with best practice erosion/sedimentation prevention techniques. These techniques should be detailed in an Erosion/Sediment Prevention Plan, including a SWPPP, which should be developed by the detailed design engineer following the State of Florida Erosion and Sediment Control Designer and

Reviewer Manual and the U.S. EPA template, or any other similar guidance. This plan should include regular inspection, monitoring and repair (as needed) of erosion/sediment prevention devices.

Additional survey, field investigation, and detailed design are required to develop the Erosion/Sediment Prevention Plan.

Soil Compaction

Construction vehicles have the potential to compact in-situ soils on the site during the performance of construction operations. This could lead to reduced infiltration into the soil and a corresponding increase in runoff. This possible situation could have a potential impact on the CMW, Meagre Bay Pond, the freshwater lenses and developed areas. The following are potential mitigation measures for this potential impact.

Compaction of the soil could be reduced with the use of low-impact construction vehicles and/or mats. Low-impact vehicles could include soft-track vehicles or vehicles with low tire pressure that can traverse the peat and wetland areas while minimising potential soil damage. Implementation of load-distributing construction access methods such as timber mats, load confinement cell geomembranes or other methods should be considered to reduce soil compaction potential in sensitive areas. In addition, any increase in flooding potential should be taken into account in the analysis of the mitigation considerations recommended in the previous sections.

Additional geotechnical information is required to identify locations where soil compaction measures are needed.

Site Infrastructure and Staff Safety

Severe rainfall runoff and storm surges resulting from extreme weather events have the potential to inundate the construction site for the Proposed Project. This issue is only related to the extent of the construction area.

To account for the potential hazards of flooding on the site, a Flood Hazard Management Plan should be developed that details procedures for addressing emergency flooding events and flood prevention techniques during construction. This plan should involve grading of surfaces to direct floodwater away from construction equipment and evacuation routes. The plan should follow the principles for temporary drainage treatments as described in the FDOT Drainage Manual and Drainage Design Guide or any other similar guidelines. The detailed design of the project should also consider construction flooding concerns when developing the site layout.

Additional survey, field investigation, detailed design, and geotechnical data will be required to develop the site layout and grading plans as well as develop a Flood Hazard Management Plan.

Table 12-27: Mitigation Measure Considerations for Hydrology and Drainage Resources during the Construction Phase

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measure Considerations</th><th>Magnitude</th><th>Geographic Extent</th><th>Timing</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">CMW, Meagre Bay Pond, Freshwater Lenses, Developed Areas/ Hydrology, drainage, and flooding</td><td rowspan="2">Temporary storage, stockpiling of materials and construction phases may change runoff patterns and locally increase flood risk</td><td rowspan="2">Proper siting of temporary stockpiles; construction access and a properly designed temporary construction drainage plan to maintain existing drainage patterns and hydrologic connectivity throughout construction. As part of the Construction Risk Management Process, that requires regular reviews, actions will be implemented to minimise the impact of any flooding incident observed during construction process (outside of the EIA).</td><td>L</td><td>LOD</td><td>A</td><td>ST</td><td>R</td><td>R</td><td rowspan="2">Minor, localised flooding</td><td rowspan="2">Not significant-mitigation measures would limit any minor, local flooding effects during construction</td></tr>
<tr><td colspan="6">Assuming mitigation measures are applied, the magnitude of the impact would be Low.

Any minor flooding effects would be experienced within the LOD.

Timing is Applicable. Seasonal changes could impact the flooding severity as precipitation increases from June – October.

Any minor flooding effects caused by construction would only last the length of construction activities, causing a Short-Term duration.

Minor flooding effects may occur with Regular frequency due to local weather patterns.

Mitigation efforts would reduce the risk and severity of flooding. After construction ceases, flow patterns would revert to the proposed design state and be considered Reversible.</td></tr>
</table>

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measure Considerations</th><th>Magnitude</th><th>Geographic Extent</th><th>Timing</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">CMW, Meagre Bay Pond, Freshwater Lenses, Developed Areas/ Pollution</td><td rowspan="2">Construction equipment may release contaminants that pollute surface waters, sensitive habitats and the underlying aquifers</td><td rowspan="2">Regular inspection of construction equipment; Identification of areas for maintenance, re-fuelling and storage away from natural resources; Development and implementation of a spill emergency and response plan and/or a complete Stormwater Pollution Prevention Plan (SWPPP)</td><td>L</td><td>OLOD</td><td>A</td><td>LT</td><td>Oc</td><td>NR</td><td rowspan="2">Minor, localised contamination</td><td rowspan="2">Not Significant- mitigation measures would limit any minor, local contamination effects during construction</td></tr>
<tr><td colspan="6">Assuming mitigation measures are applied, the magnitude of the impact would be Low.

The impact would extend Outside the LOD as wind and water transport pollutants.

Timing is Applicable; the impact may vary seasonally. Precipitation increases from June – October, causing more runoff and a higher likelihood of pollutants spreading further.

The impact could be Long-Term and may not be able to be remedied within a specific timeframe.

The frequency might be Occasional until the end of construction.

Mitigation may not be able to completely restore polluted areas, making this impact Not Reversible</td></tr>
</table>

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
CMW, Meagre Bay Pond, Developed Areas/Erosion and Runoff	Sediment-laden runoff may pollute surface waters and sensitive habitats	Limiting vegetation clearing to active construction areas; Using best practice erosion/sedimentation prevention techniques; Regular inspection of erosion/sediment prevention devices; Repair of erosion/sediment prevention devices as needed; Stabilization of site after work has been completed; Regular inspection/monitoring integrated into consolidated SWPPP	L	LOD	A	ST	R	R	Minor, localised erosion and sedimentation	Not Significant-mitigation measures would limit any minor, local erosion and sedimentation effects during construction
			Assuming mitigation measures are applied, the magnitude of the impact would be Low. Mitigation measures should limit erosion to the construction site; impacts will likely only occur within the LOD. Timing is Applicable. Erosion and runoff may worsen seasonally as precipitation increases from June – October. The impact duration would be Short-Term as the site will be stabilized once construction is complete. The frequency would be Regular based on the climate and occurrence of precipitation events. The impact is Reversible as the site will be in a stabilized condition after construction is complete.								

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
CMW, Meagre Bay Pond, Freshwater Lenses, Developed Areas/Soil Compaction	Construction equipment may cause soil compaction, which may result in reduced infiltration and increased runoff	Reduction in soil compaction with the use of low-impact construction vehicles, construction access mats or other construction vehicle load distribution methods	L	LOD	A	LT	C	NR	Minor, localised soil compaction	Not Significant- mitigation measures would limit the severity of any minor, local soil compaction effects
			Assuming mitigation measures are applied, the magnitude of impact would be Low. Only the soil within the LOD would be impacted. With more precipitation from June – October, timing is Applicable. The soil may be wetter and more easily compressed. The impact would have a Long-Term duration, lasting even after construction is complete. Soil compaction would be Continuous for the duration of construction. The impacts would be considered Not Reversible as it would not be possible to reverse the compaction after construction is complete.							

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Site Infrastructure and Staff Safety	Rainfall runoff, extreme weather and climate change induced flood events may inundate the construction site	Consideration of Site layout in the project Detailed Design; Grading of surfaces to direct floodwater away from equipment and evacuation routes; Creation of a flood hazard management plan	L	LOD	A	ST	R	R	None	None - mitigation measures would be designed to prevent damage and endangerment of site equipment and personnel
			Assuming mitigation measures are applied, the magnitude of the impact would be Low. Only materials and staff within the LOD would be impacted. Timing is Applicable. Rainfall and therefore potential flooding may worsen from June – October. Impacts would have a Short-Term duration as the construction site would only be active through construction. Frequency would be Regular as flooding would occur based on local climate and weather patterns. Conditions would return to baseline after construction is complete, making it a Reversible impact							

12.5.2 Operation Phase

During roadway operation (post-construction), measures can be implemented to potentially prevent and reduce impacts on and off-site. The following section discusses potential mitigation measure considerations that could be used to address the impacts to the identified hydrology and drainage elements. **Table 12-28** summarizes the potential impacts and mitigation measure considerations. Additional mitigation considerations for the CMW, Mastic Reserve, and Meagre Bay Pond are described in **Chapter 13: Terrestrial Ecology** and **Chapter 14: Cultural and Natural Heritage**.

Hydrology and Drainage

The hydrology and drainage elements within and adjacent to the Proposed Project area have the potential to be impacted during the operations life of the project. The proposed roadway layout and bridge/culvert configurations have the potential to change surface water and extreme weather drainage patterns as well as regionally change flood risks. These changes could potentially affect the CMW, Meagre Bay Pond, Mastic Reserve and developed areas. The following are several mitigation measures that could be incorporated into the detailed design to potentially reduce these potential impacts.

The general roadway drainage conveyance design can consider the use of closed conduit drainage systems (e.g., inlets, pipes, manholes, etc.) as opposed to the drainage wells that are traditionally used on the Island. Open drainage ditches may also be used in conjunction with closed conduit systems to convey surface runoff. The design of open and closed drainage systems should follow the Grand Cayman Planning Department's Grand Cayman Stormwater Management Guidelines and the FDOT Drainage Manual and Drainage Design Guide or any other similar guidelines. These documents provide guidelines on preventing roadway flooding from smaller, more frequent storms. The roadway drainage systems, as well as large culvert and bridge opening structures should be designed by the detailed design engineer following the direction in the FDOT Drainage Manual, Drainage Design Guide and Bridge Scour Manual in addition to consultation with experts in the field of coastal engineering. These resources can assist in guiding the detailed design to handle flooding from larger, more extreme storm events. The FDOT Drainage Manual and Drainage Design Guide also provide directions for incorporating sea level rise into the detailed design that should be followed. Road closure potential from flooding during large stormwater events should be determined and addressed based on current Grand Cayman procedures.

Additional survey and geotechnical data are required to perform required hydrologic and hydraulic modelling, particularly through the portion of the CMW that is traversed by the Proposed Project. The initial modelling that has been performed to date, and is referenced in this chapter, does not cover localised drainage systems; and is only at "proof-of-concept" level for the conceptual analysis that was used to estimate the number, size and locations of the potential roadway bridge opening structures. Descriptions of these potential structures are contained in **Section 6.6.7: Hydraulic Structures** of this document. As part of the detailed design, a detailed rainfall and storm surge modelling analysis should be completed by a qualified expert in the field to determine the final bridge opening structure configurations to be constructed along the Proposed Project.

Pollution

Runoff from the Proposed Project has the potential to carry pollution from vehicles using the facility out into the surrounding areas. This runoff has the potential to affect the water quality in the CMW, Meagre Bay Pond, freshwater lenses and developed areas. There are several potential mitigation measures that could be used to reduce these impacts.

Volume 2 of the Environmental Resource Permit Applicants Handbook for the SFWMD and Chapter 62-777 of the Florida Administrative Code provide guidelines for water quality requirements and water quality treatment methods. These guidelines or any similar aid in ensuring the drainage infrastructure and stormwater management detailed design minimise water quality impacts. Green Stormwater Infrastructure and Low Impact Design and Development (LID) approaches should also be evaluated. Prince George's County, Maryland's Department of Environmental Resources Low-Impact Development Design Strategies; An integrated Design Approach is recommended for guidance in selecting alternative environmental water quality treatment features. It is also recommended to use linear treatment systems such as landscape buffers adjacent to ditches or where roadway runoff "sheet flows" to adjacent resource areas to filter roadway runoff. These applications provide treatment for the roadway runoff without potentially requiring excess additional property and the resulting corresponding impacts.

Additional survey, detailed design, and geotechnical data are required to design and model stormwater infrastructure and to develop a Stormwater Management Plan.

Erosion and Runoff

The increase in impervious area due to the paved roadway surface will increase the volume of stormwater runoff along with the velocity of runoff. This may increase erosion along the side slopes of the Proposed Project and at the drainage system outfall points. In addition, concentrated flow through the roadway opening structures has the potential to cause scour and erosion in the immediate vicinity of the roadway openings. This type of erosion could potentially result in sediment laden waters leaving the project site. This potential condition could have an effect on the CMW, Meagre Bay Pond and developed areas. The following are a few potential mitigation measures to consider for this impact.

The detailed design should identify stable locations for the drainage system outfall points, and the outfall points should be evaluated for runoff velocity and should incorporate some form of protection and/or energy dissipation as needed. The FDOT Drainage Manual and Drainage Design Guide or similar guidelines provide guidance on this topic. The initial modelling results performed to date indicated that the roadway would potentially be overtopped during extreme events and suggested that the roadside slopes be armoured to prevent erosion of the roadbed during these events. As mentioned in previous sections, consideration should be given to using scour protection (e.g., riprap) to reduce the potential for scour at the location of the culvert and bridge roadway openings.

Additional survey, detailed design, and geotechnical data are required to design for stormwater erosion impacts and protection measures.

Natural Resource Hydrology

The proposed roadway has the potential to impact the hydrology of natural resources including alteration of water flow, water levels and surface drainage patterns. This has the potential to affect the CMW, Meagre Bay Pond, freshwater lenses and Mastic Reserve. The following describes potential mitigation measures for this potential impact.

The refinement of the roadway opening locations, which would be done as part of the detailed design, would focus on avoiding disruptions to the major baseline flow patterns. This element of the detailed design should be coordinated closely with terrestrial ecology mitigation considerations to ensure that the baseline flow patterns are captured appropriately and that impacts to baseline environmental patterns are minimised (i.e., cutting off of flow to Meagre Bay Pond and isolation/drying out of wetlands on one side of the road). This analysis should also include the placement of smaller "levelling" devices along the length of the Proposed Project to ensure that no wetlands or smaller flow patterns are cut off by the roadway.

Additional survey, geotechnical investigation, and close coordination with terrestrial ecology mitigation considerations and other experts will be required during detailed design of these mitigation measures.

Natural Resource Ecology

Potential impacts to the natural resource ecology are closely associated with the natural resource hydrology impacts and could potentially result in further impacts to the CMW, Meagre Bay Pond and Mastic Reserve. The Proposed Project has the potential to change natural flow patterns and create an impact on the ecology of natural resources, including alteration of salinity levels, nutrient balance, oxygen concentration, and temperature that may be harmful to mangroves, wildlife and other ecological resources.

As with the natural resource hydrology impacts, detailed design of the roadway openings and "levelling" devices are recommended for consideration to avoid and/or minimise these potential impacts. Factors such as the location and sizing of openings as well as the use of "levelling" devices would have a direct impact on the amount and method of water crossing under the roadway. Natural processes and flow patterns should be mimicked as closely as possible with the detailed design. This will require close coordination with the terrestrial ecology mitigation considerations to avoid and/or minimise potential impacts to ecological processes on the island.

Additional survey, geotechnical investigation, and coordination with the terrestrial ecology mitigation considerations will be required during detailed design of these mitigation measures.

Mangrove Loss

The construction of the Proposed Project will involve the loss of mangroves along the roadway alignment. This loss of vegetation has the potential to reduce transpiration; decrease precipitation on the western end of the island; increase runoff and reduce floodplain roughness, which collectively could potentially increase run-off velocity; and reduce protection from tropical storms and hurricanes. These impacts could also potentially affect the CMW, Meagre Bay Pond, freshwater lenses and developed areas. The following describes potential mitigation measures for these potential impacts.

The use of linear treatment systems, such as landscape buffers, to filter roadway runoff would provide a natural treatment along the facility and should be considered during the detailed design. The potential erosion and flooding effects from the un-avoidable mangrove loss could be potentially mitigated by the measures mentioned in previous sections, such as armouring of the roadsides and utilising the proposed roadway openings to minimise flooding impacts. The location of roadway openings and "levelling" devices will need to be closely coordinated to ensure that flow to mangroves on either side of the road is not greatly altered, leading to potential impacts outside of the roadway footprint.

Similar to the hydrology and ecology impacts, these mitigation considerations to avoid/minimise continuous mangrove loss should be coordinated closely with terrestrial ecology mitigation considerations during the detailed design. Additional data requirements for these mitigation measure considerations have been described in the previous sections.

Table 12-28: Operation Phase Mitigation Considerations for Hydrology and Drainage Resources

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
CMW, Meagre Bay Pond, Mastic Reserve, Developed Areas/Hydrology and Drainage	Roadway layout and opening configuration may change surface water and extreme weather drainage patterns and regionally change flood risk	Proper design of the localised drainage systems to handle flooding from smaller, more frequent storms; Proper design of the road and the opening structures under the road to handle flooding from larger, more extreme storms; Design stormwater systems to be effective with rising sea level	L	OLOD	A	LT	R	NR	Areas may experience slightly higher or lower peak flooding elevations and slightly longer flood durations based on preliminary modelling	Not Significant- mitigation measures would limit difference in flood elevations to acceptable values
			A Low magnitude of impact would be expected as the preliminary modelling performed indicated only slight variance from the baseline flooding conditions. Impacts may occur Outside the LOD due to changes in flood patterns. Timing is Applicable. From June – October precipitation increases resulting in more potential runoff and flooding. The impact would have a Long-Term duration, persisting as long as the road is in place. The frequency would be Regular based on local and regional weather patterns. Impacts would be considered Not Reversible since the changes to drainage patterns would be permanent.							

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
CMW, Meagre Bay Pond, Freshwater Lenses, Developed Areas/Pollution	Vehicles on the proposed road may release contaminants that runoff and pollute surface waters, sensitive habitats and the underlying aquifers	Design drainage infrastructure and stormwater management design to minimise water quality impacts; Potential use of Green Stormwater Infrastructure and Low Impact Design or Development (LID) approaches including linear treatment systems and landscape buffers to filter roadway runoff; Regular water quality monitoring in key locations	L	LOD/ OLOD	A	LT	C	PR	Minor contamination	Not Significant- mitigation measures would limit any minor contamination effects
			Assuming mitigation measures are applied, the magnitude of the impact would be Low. Impacts would be anticipated both within and Outside the LOD as pollutants on the highway spread via runoff. Timing is Applicable. Seasonal changes may likely impact contaminant spread. From June – October precipitation increases causing more runoff and, in turn, a higher likelihood of spreading contaminants. The impact would have a Long-Term duration and would persist as long as the road is in place. The impact would be Continuous since the highway would be in constant use. Effects would be considered Partially Reversible as mitigation efforts would likely only partially restore conditions to baseline, depending on the pollutant.								

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
CMW, Meagre Bay Pond, Developed Areas/Erosion and Runoff	Increase of stormwater runoff volume and velocity which may increase erosion and flooding in areas adjacent to the road	Identify stable locations to discharge stormwater from the roadway; Provide armouring for the roadside slopes; Design scour protection and abutment protection for the roadway opening structures	L	LOD/ OLOD	A	LT	R	NR	Minor erosion and sedimentation	Not Significant- mitigation measures would limit any minor erosion and sedimentation effects
			Assuming mitigation measures are applied, the magnitude of the impact would be Low. Impacts would occur both within and Outside the LOD as runoff would leave the roadway footprint at outfall points. Timing is Applicable. The seasonal increase of rain from June – October would increase run-off volume and velocity. The impact would have a Long-Term duration and would persist as long as the road is in place. The frequency would be Regular, following weather patterns. The impact would be considered Not Reversible since the highway is a permanent structure.							

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measure Considerations</th><th>Magnitude</th><th>Geographic Extent</th><th>Timing</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">CMW, Meagre Bay Pond, Freshwater Lenses, Mastic Reserve/Natural Resource Hydrology</td><td rowspan="2">Impact on the hydrology of natural resources including alteration of water flow, water levels and surface drainage that may be harmful to the CMW, Mastic Reserve and Meagre Bay Pond</td><td rowspan="2">Design roadway openings to maintain water flow between both sides of the road; Use culverts or other “levelling” devices along the length of the corridor; Place openings to avoid hydrologic disconnection of wetlands and other impacts</td><td>L</td><td>LOD/ OLOD</td><td>A</td><td>LT</td><td>R</td><td>NR</td><td rowspan="2">Minor hydrologic changes to natural resources</td><td rowspan="2">Not Significant- mitigation measures would limit any minor hydrologic changes to natural resources</td></tr>
<tr><td colspan="6">Assuming mitigation measures are applied, the magnitude of the impact would be Low.

Impacts may occur both within and Outside the LOD to natural resources whose hydrology crosses over the project area.

Timing is Applicable. The rainfall that drives hydrology for natural resources experiences seasonal variation.

The impact would have a Long-Term duration and would persist as long as the road is in place.

The frequency would be Regular, following weather patterns.

Impacts would be considered Not Reversible since the changes to drainage patterns would be permanent.</td></tr>
</table>

Resource	Potential Effect	Mitigation Measure Considerations	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
CMW, Meagre Bay Pond, Mastic Reserve/Natural Resource Ecology	Impact on the ecology of natural resources including alteration of salinity levels, nutrient balance, oxygen concentration and temperature that may be harmful to mangroves, wildlife and other ecological resources	Design roadway openings to maintain water flow and mimic natural flow patterns between both sides of the road; Use culverts or other "levelling" devices along the length of the corridor in addition to the roadway opening structures	L	LOD/ OLOD	A	LT	R	NR	Minor ecological changes to natural resources	Not Significant- mitigation measures would limit any minor ecological changes to natural resources
			Assuming mitigation measures are applied, the magnitude of the impact would be Low. Impacts may occur both within and Outside the LOD to natural resources whose ecology crosses over the project area. The rainfall that drives the ecology for natural resources experiences seasonal variation; timing is Applicable. The impact duration would be Long-Term and would persist as long as the road is in place. The frequency would be Regular, following weather patterns. Impacts would be considered Not Reversible since the changes to drainage patterns would be permanent.							

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measure Considerations</th><th>Magnitude</th><th>Geographic Extent</th><th>Timing</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">CMW, Meagre Bay Pond, Freshwater Lenses, Developed Areas/Mangrove Loss</td><td rowspan="2">The loss of mangroves in the site footprint reduces transpiration, may decrease precipitation on the western end of the island, may increase runoff and could reduce floodplain roughness, which in turn could increase run-off velocity and reduce protection from tropical storms and hurricanes</td><td rowspan="2">Use linear treatment systems to filter roadway runoff and minimise roadway footprint; Proper erosion protection and roadway opening detailed design; Roadway opening and “levelling” device placement to avoid hydrologic disconnection of mangrove wetlands</td><td>M</td><td>LOD/ OLOD</td><td>NA</td><td>LT</td><td>O</td><td>NR</td><td rowspan="2">Loss of mangroves within the roadway footprint</td><td rowspan="2">Not Significant- see Chapter 13: Terrestrial Ecology for mitigation measures regarding terrestrial ecology (including mangrove) functional loss</td></tr>
<tr><td colspan="6">The magnitude of the impacts to the area would be Medium as it is desired that no mangroves be removed. However, the percentage of mangroves being removed compared to the entire CMW is very small.

Assuming mitigation measures are applied, the mangrove loss would only occur within the LOD. However, the effects of the mangrove loss would extend Outside of the LOD.

The impact would not be dependent on seasonal variations; timing is Not Applicable.

The impact would have a Long-Term duration since the removal of mangroves on-Site would be permanent.

The mangrove removal would only occur during the construction of the road; the frequency would be Once

The impact would be considered Not Reversible as mitigation would not be able to return the site to Baseline Conditions.</td></tr>
</table>

12.5.3 Summary of Hydrology and Drainage Mitigation Measure Considerations

Mitigation measure considerations during construction primarily consist of preventive and best management practices and monitoring to potentially reduce impacts during construction. Preventative and best management measures include siting of temporary stockpiles; design of construction access and a temporary Construction Drainage Plan; identification of vehicle maintenance areas; development of a Spill Emergency and Response Plan and/or a Stormwater Pollution Prevention Plan (SWPPP); limiting vegetation clearing to active construction areas; using best practice erosion/sedimentation prevention devices; stabilization of site after work has been completed; use of low-impact construction vehicles/mats/other low-impact methods; consideration of site layout during detailed design; grading of surfaces to direct floodwater away from equipment and evacuation routes; and creation of a Flood Hazard Management Plan. Monitoring measures include inspection of construction equipment and inspection and repair of erosion/sediment prevention devices. Regular evaluation and betterment of the mitigatory measures implemented is expected to be considered as part of Construction Management Plan (outside of the EIA).

Mitigation measure considerations during operation will consist of measures to avoid and/or minimise potential impacts. Localised drainage systems and larger drainage structure openings under the road could be designed to handle appropriate rainfall events and account for rising sea levels. Stormwater management features, such as linear treatment systems and landscape buffers, could be designed with consideration for Green Stormwater Infrastructure and LID approaches to minimise water quality impacts. Appropriate erosion and scour countermeasures, such as roadway opening abutment protection and stable outfall locations, could be used to prevent erosion contamination of nearby water resources. In addition, culverts or other “levelling” devices could be designed, in addition to the proposed roadway opening structures, to best avoid or reduce hydrologic disconnection of wetlands and aid in avoiding or minimising impacts to the natural resource hydrology and ecology. Potential continuous mangrove losses could be minimised with treatments such as the use of linear stormwater treatment systems and the placement of roadway opening and “levelling” devices to avoid hydrologic disconnection of mangrove wetlands.

Additional information regarding implementation, responsibilities for implementation, any monitoring and reporting, and actions for non-compliance will be included as part of the separate EMP. Due to the phased development of the project, a review of the mitigation measures and design solutions will be continually evaluated during the design, construction, and operation phases to allow for successful mitigation. If the mitigation measure considerations are not implemented, the Moderate Adverse impact to hydrology and drainage resources (**Section 12.4.2.3: Overall Assessment Score**) would remain.

13 Terrestrial Ecology

The EIA Scoping Opinion identified potential impacts to natural resources by construction and operation of the proposed EWA Extension Corridor to be a primary concern. Specifically, how the corridor could significantly affect terrestrial ecological resources directly from construction activities and indirectly through operation of the roadway; thereby, resulting in a loss of function and value. Government commitments under the Cayman Islands Environmental Charter, NCA, and the National Biodiversity Action Plan (NBAP) require that this functional loss be evaluated with the goal of achieving No Net Loss of Biodiversity.

This terrestrial ecology chapter of the ES focuses on the following:

- Describes the methodology for terrestrial ecology assessments.
- Establishes Baseline Conditions within the Study Area.
- Identifies the potential benefits and adverse impacts due to the Proposed Project, including construction and operation phases.
- Assesses the significance of these potential impacts.
- Offers avoidance, minimisation, and mitigation considerations for the project's potential negative terrestrial ecology impacts.

This chapter assesses the effects of the Proposed Project, including Section 2, Section 3, and the Will T Connector, described in **Chapter 6: Proposed Project – Engineering Features**. Baseline Conditions, which equate to Existing Conditions, are established to demonstrate the terrestrial ecology environment of Grand Cayman. The Future No-Build condition is assumed to require no additional construction or terrestrial ecological impacts. Accordingly, within this terrestrial ecology chapter, the Baseline Conditions (synonymous with Existing Conditions) are assumed to be maintained for the Future No-Build condition.

13.1 Constraints and Limitations

The evaluation of terrestrial ecology is primarily based on a desktop review of resources, with limited ground truthing validation. The primary limitation of the evaluation includes the lack of documented species habitats/densities data within the CMW, and sections of the Proposed Project being inaccessible (e.g., the CMW). Along with inaccessibility, the Proposed Project is large and evaluating the extent and ecological value of each habitat within the Proposed Project was not feasible. Owing to these constraints, a large extrapolation was used to map and assign ecological value to the habitats in the Proposed Project. The data produced through field review, habitat mapping, and extrapolation does, however, provide a reasonable representation of the Baseline Conditions within the Proposed Project.

13.2 Stakeholder Consultation

A kick-off meeting was held with the DoE and NT to discuss terrestrial ecology and cultural and natural heritage on July 19th, 2023. The project study team provided an overview of the project goals and objectives, discussed data requests for the DoE and NT, collected project information from the agencies, and presented study methodology proposed for the project. The NT presented their concerns surrounding direct primary habitat impacts, habitat fragmentation, induced development, and wildlife roadkill. For unavoidable impacts that would result from the project, the NT proposed conserving additional primary habitat as a possible mitigation measure. Based on the resources identified for potential direct impacts, the NT and DoE were noted as the applicable stakeholders to consult at this stage of the project. See **Appendix E: Shortlist [Alternatives] Evaluation, Attachment G - Cultural and Natural Heritage – Assessment of Alternatives** for more details and meeting minutes.

13.3 Assessment Methodology

Baseline Conditions of the terrestrial ecosystem were identified as a fundamental step in the preliminary assessment in determining the potential effects to the terrestrial ecosystem from the proposed EWA Extension Corridor. A desktop analysis was carried out using the technical reports, publications, government documents, websites, spreadsheets, and geographic information systems (GIS) datasets listed in **Appendix E - Shortlist [Alternatives] Evaluation: Attachment F - Terrestrial Ecology – Assessment of Alternatives**. Results from the desktop review aided in field work planning and data collection. The first field review was conducted in July of 2023 within a larger assessment area called the EIA Study Area to collect data within, adjacent to, and in the vicinity of the EWA Extension Corridor. The second field review was conducted in May of 2024 and focused on the areas within, adjacent to, and in the vicinity of the Proposed Project corridor. **Figure 13-1** depicts both the EIA Study Area and the Proposed Project, which includes Section 2, Section 3, and the Will T Connector.

This section discusses the methodology associated with determining impacts to terrestrial habitats that could result from the Proposed Project. The methods included a desktop review to determine locations of field verification points for a second field review, field review to document habitat type and quality based on use of the Uniform Mitigation Assessment Method (UMAM), updating the habitat map for the Proposed Project based on the collected field data, conducting a functional assessment of the habitats within the Proposed Project based on UMAM analysis conducted on the 2023 and 2024 field verification points, a qualitative assessment based on the UK Department for Transport's WebTAG, and a monetary assessment based on the 2020 Cayman Islands Ecosystem Accounting. These methods are described in more detail in **Sections 13.3.1 – 13.3.6** of this chapter.

Figure 13-1: Map of EIA Study Area

13.3.1 Desktop Review

A desktop review was conducted to determine locations for new field verification points to fill in gaps from the 2023 field evaluation and to build a better understanding of the ecological Baseline Conditions of the Proposed Project. The objectives of the May 2024 field effort were to refine habitat mapping for the Proposed Project, collect more information on habitat values, and identify potential locations for compensatory mitigation. The Proposed Project had not been selected at this stage of the project; therefore, the selection of field verification points had to consider shortlisted Alternatives B1, B2, and B3 and focus on locations where data could be collected that would be relevant to any of these alternatives (see **Appendix E – Shortlist [Alternatives] Evaluation** for more details on the shortlisted alternatives).

Data reviewed to select field verification points included the habitat maps developed for these alternatives, the 2023 field verification points, and aerial photographs of Grand Cayman. As experienced during the 2023 field evaluation, accessibility to some areas was limited either by landowners or by impenetrable terrain (such was the case for the CMW). With knowledge of accessibility limitations, field verification points were selected in locations that could best translate to the habitats located in inaccessible areas. Such locations included along the outskirts of the CMW near adjacent quarry sites, along access roads near mosquito ditches in the southeast corner of the CMW, and near the Mastic Trail. A total of 39 field verification points was selected. When combined with the 53 field verification points collected in 2023, a total of 92 field data points was collected (see **Appendix E - Shortlist [Alternatives] Evaluation: Attachment F - Terrestrial Ecology – Assessment of Alternatives** for information on the 2023 field reconnaissance). The field verification points can be seen in **Figures 13-2a** and **13-2b**.

As documented in **Appendix E - Shortlist [Alternatives] Evaluation: Attachment F - Terrestrial Ecology – Assessment of Alternatives**, a large swath of the CMW from Bodden Town to North Side appeared to be of lower density than the surrounding CMW (**Figure 13-3**). The **Shortlist [Alternatives] Evaluation: Attachment F – Terrestrial Ecology – Assessment of Alternatives** provides more detail about how this area was identified. Part of the goal of the 2024 field review was to better understand the habitat value within this "low density" area and field verification points within and adjacent to this area were selected as part of the process previously described.

Figure 13-2a: Map of Field Verification Points (Western Side of EIA Study Area)

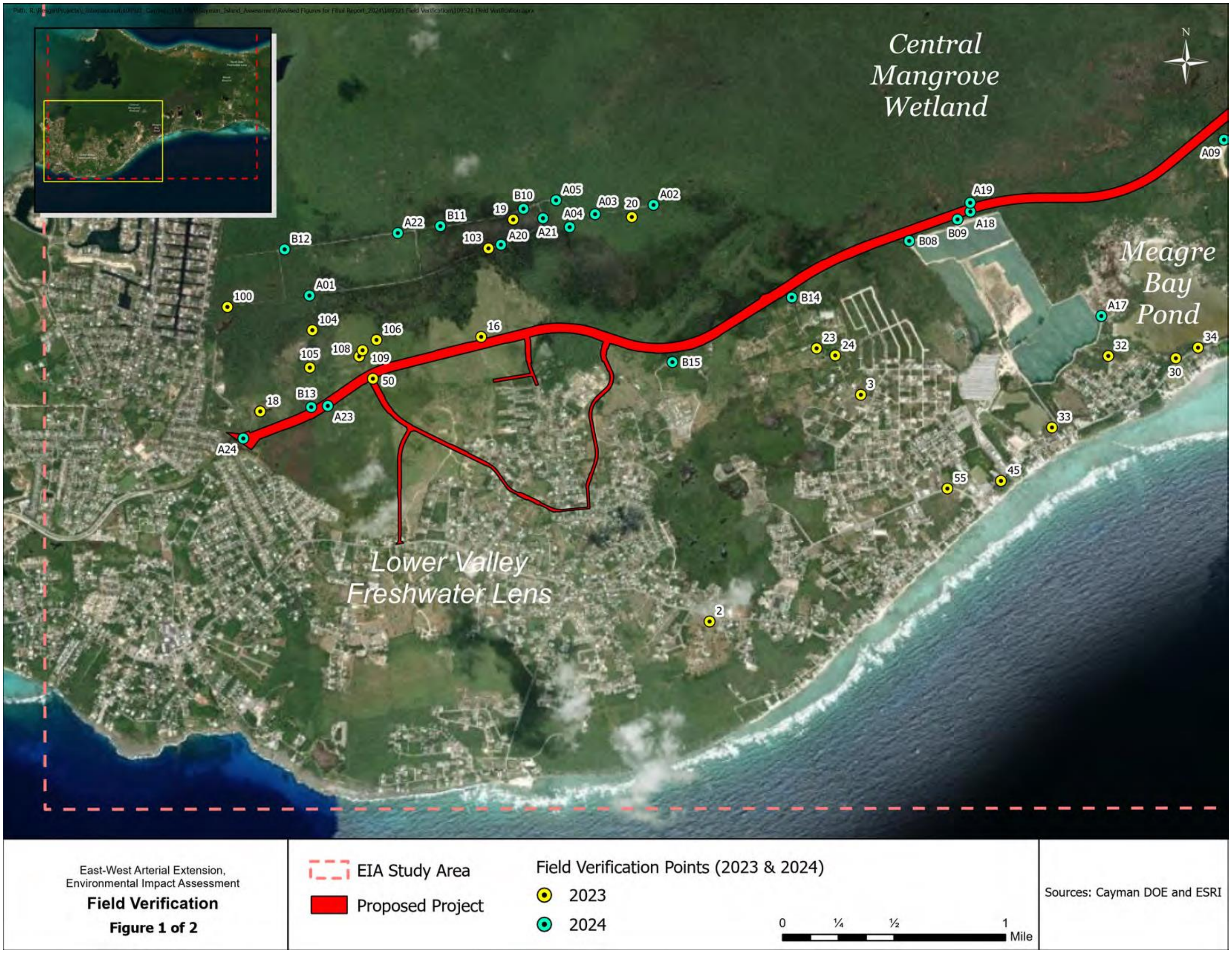


Figure 13-2b: Map of Field Verification Points (Eastern Side of EIA Study Area)

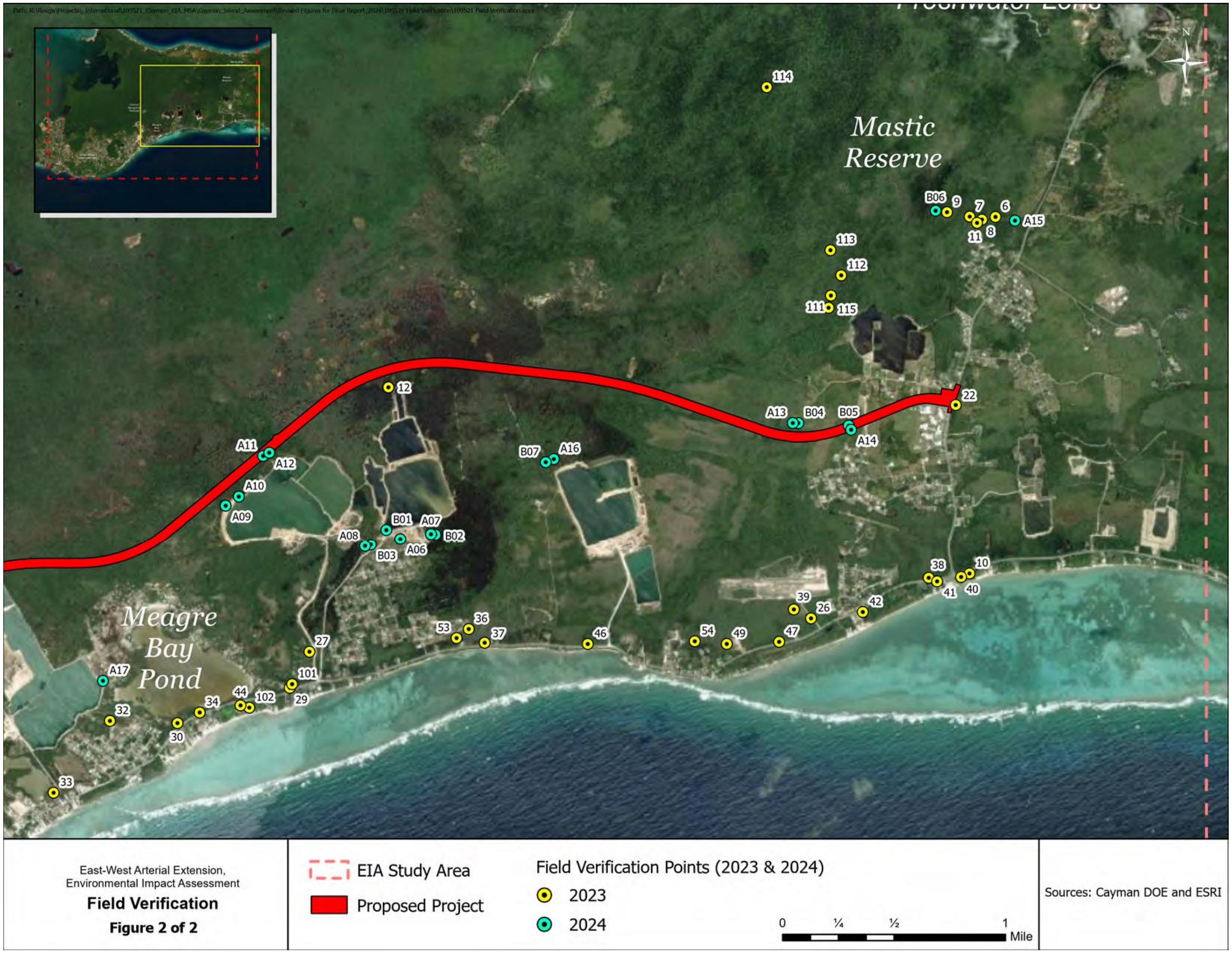
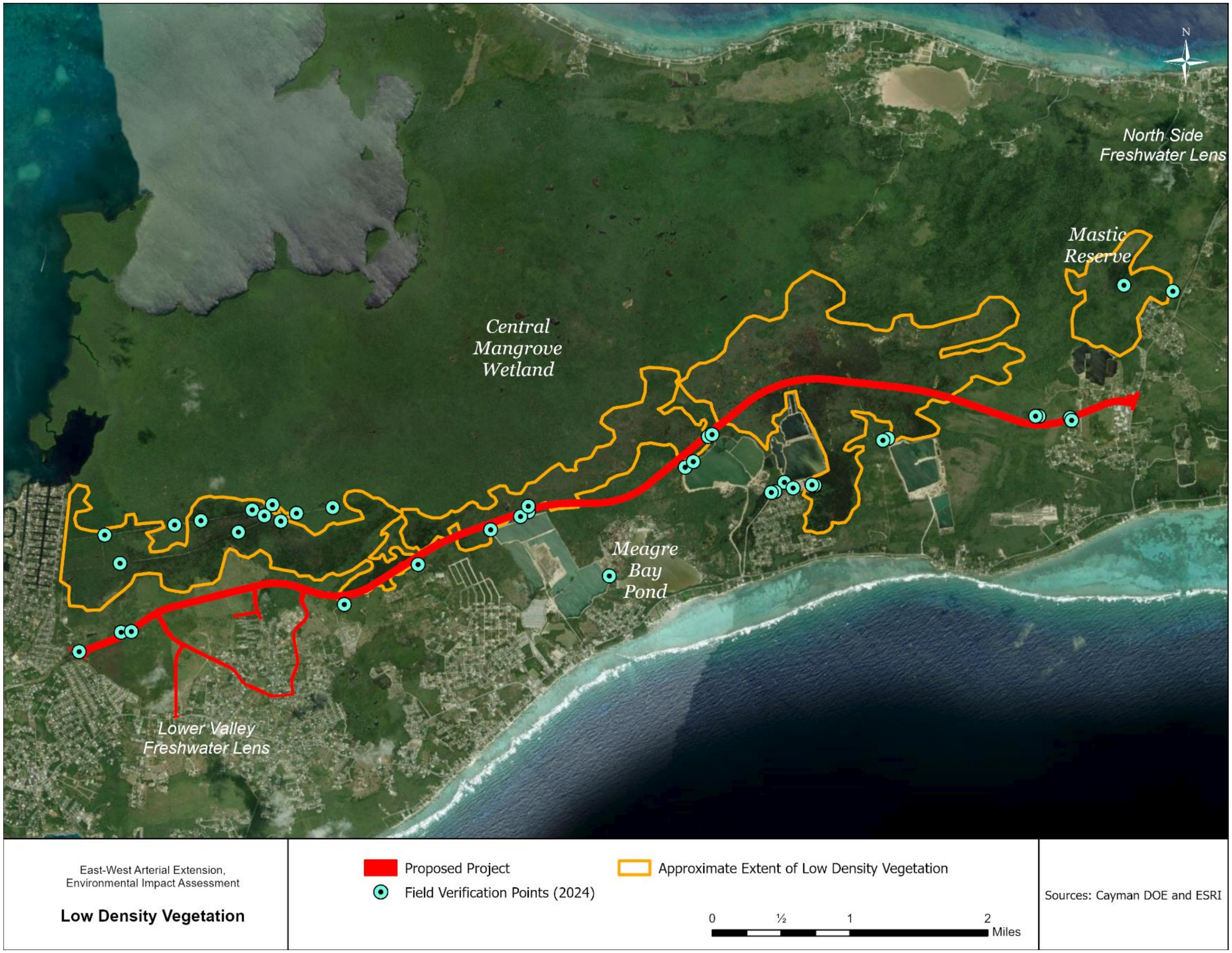


Figure 13-3: Map of Low-Density Vegetation



13.3.2 Field Evaluations

The terrestrial ecology team conducted on-site field verifications and evaluations on May 13th – 17th, 2024. During these field evaluations, ecologists observed and noted habitat type and condition, vegetative species, and wildlife, while completing UMAM assessments. A detailed description of the UMAM assessment methodology is provided in **Section 13.3.5: Qualitative Assessment** of this chapter. The data collected during this field review was used to refine the habitat map for the Proposed Project.

13.3.2.1 Functional Assessment of Habitats

In general, a functional habitat assessment is conducted to quantify habitat value based on the benefits and services it provides to an ecosystem. Quantified habitat value is then used to determine functional loss and estimated mitigation for habitat impacts. The Biodiversity Metric 3.1 Calculation Tool was developed by Natural England[4] to determine mitigation measures for No Net Loss of Biodiversity resulting from a project. The Biodiversity Metric was evaluated for use on this project; however, the habitats found on Grand Cayman are not included in the Biodiversity Metric and thus the metric will not work to determine functional value and loss as well as mitigation for these habitats. Consequently, another functional assessment and mitigation calculation was required. The ToR for this project identified the UMAM as the most relevant assessment given its utility in Florida assessing sub-tropical climates and habitats similar to those found on Grand Cayman.

Uniform Mitigation Assessment Method (UMAM)

The UMAM is a functional assessment method used by the State of Florida in the U.S. of America. The UMAM provides a standardized procedure for assessing the ecological functions provided by wetlands, the amount that those functions are reduced by a proposed impact, and the amount of mitigation necessary to offset that loss. The UMAM evaluates habitat value within an assessment area (AA) through considerations of the current condition of the AA being evaluated, hydrologic connection, uniqueness, location, and fish and wildlife utilisation. The UMAM is broken down into three assessment categories, listed as follows.

- Location and Landscape Support;
    - Quality and quantity of habitat support outside of the AA
    - Invasive plant species
    - Wildlife access to and from AA (proximity and barriers)
    - Downstream benefits provided to fish and wildlife
    - Adverse impacts to wildlife in AA from land uses outside of AA
    - Hydrologic connectivity (impediments and flow restrictions)
    - Dependency of downstream habitats on quantity or quality of discharges
    - Protection of wetland functions provided by uplands (upland AAs only)

[4] Natural England is the government's advisor for the natural environmental in England (About us - Natural England - GOV.UK)

- Water Environment;
  - Appropriateness of water levels and flows
  - Reliability of water level indicators
  - Appropriateness of soil moisture
  - Flow rates/points of discharge
  - Fire frequency/severity
  - Type of vegetation
  - Hydrologic stress on vegetation
  - Use by animals with hydrologic requirements
  - Plant community composition associated with water quality (e.g., plants tolerant of poor water quality)
  - Water quality of standing water by observation (e.g., discoloration, turbidity)
  - Water quality data for the type of community
  - Water depth, wave energy, and currents
- Community Structure.
  - Appropriate/desirable species
  - Invasive/exotic plant species
  - Regeneration/recruitment
  - Age, size distribution
  - Snags, dens, cavity, etc.
  - Plants' condition
  - Land management practices
  - Topographic features (refugia, channels, hummocks)
  - Submerged vegetation (only score if present)
  - Upland assessment area

The score for each of the three categories is the average score of each associated sub-category. Sub-categories and categories are scored on a scale of 0-10, with 10 being the highest score. The scores of the categories are then added and divided by 30 to give the score for the assessment area. This method is used to calculate the score of the "current" conditions in the AA and the score of the conditions of the AA following an impact, called the "with impact" score. For a total impact within a category or subcategory a value of zero is given. Not all impacts result in a total loss of function; therefore, the estimated loss of function should be carefully considered. The functional loss based on the proposed impact is then calculated by subtracting the "with impact" score from the "current" conditions score to give the impact delta. The impact delta is multiplied by the impact acres to calculate the functional loss. **Table 13-1** provides an example of calculating functional loss with UMAM. UMAM is also used to calculate the amount of compensatory mitigation required for an impact. These methods are described in **Section 13.3.4: Mitigation Assessment** of this chapter.

$$Functional\ Loss = (Current\ Conditions\ Score - With\ Impact\ Score) \times Impact\ Acres$$

Table 13-1: Example Functional Loss Calculation with UMAM

Assessment Area (AA) 1		
Category	**Score (Current Conditions)**	**Score (With Impact)**
Location and Landscape Support	6	6
Water Environment	4	0
Community Structure	5	1
Raw Score	0.50	0.23
Impact Delta	0.27	
Impact Acres	1	
Functional Loss	0.27	

UMAM Assessment

During the 2023 and 2024 field evaluations, UMAM sheets were filled out to document and determine the current condition score for the 92 field verification points. Of those points, 69 field verification points had applicability to the Proposed Project (i.e., were for habitats found in the Proposed Project). Therefore, total loss of function was assumed for the habitats within the Proposed Project footprint. The UMAM, for the remaining field verification points, are not described in this chapter but can be reviewed in **Appendix K.1: UMAM Mapping and Sheets** with the UMAM sheets for the 92 field verification points. The results of the UMAM analysis are provided in **Section 13.4.2.3: Habitat Quality/Functionality** in this chapter.

Caveats and methodology adaptation

The UMAM is an assessment tool used for wetlands and is not used to assess the value of upland habitats given that the scoring criteria considers factors relating to the water environment. However, for this analysis, the UMAM was adapted to assess the value of upland habitats by removing the water environment scoring criteria. Therefore, the current conditions score for these assessment areas were obtained by adding the location and landscape support and community structure score and dividing by 20 instead of 30. Heavily man-modified land uses do not offer habitat value; however, some man-modified land uses such as man-modified with trees, man-modified without trees, and pasture can offer marginal habitat benefits even as limited as marginal foraging and sheltering opportunities. Therefore, these man-modified land uses were evaluated with the UMAM. The commercial, institutional, residential, and roads land uses were left out of the evaluation.

13.3.3 Post-Field Evaluation Habitat Mapping

The habitat map for the Proposed Project, originally developed during the Assessment of Alternatives in July 2023, was revised based on data collected during the 2024 field effort. The 39 new field verification points were overlain atop the habitat map. Field verification points that fell on the habitat limits or outside of these limits, but within the same perceived habitat (from visual interpretation of satellite imagery) were cross referenced with the habitat map (**Figure 13-4**). In instances where the habitat type signified by the field verification point differed from the habitat map, that habitat type was changed in the map. An area of habitat located near the eastern terminus of the Proposed Project was revised to reflect recent land clearing (**Figure 13-5**). Also, the entire habitat map was closely analysed to identify locations where the extents of habitats could be refined based on visual interpretation of satellite imagery.

Figure 13-4: Example of 2024 Field Verification Points Used to Revise Habitat Map

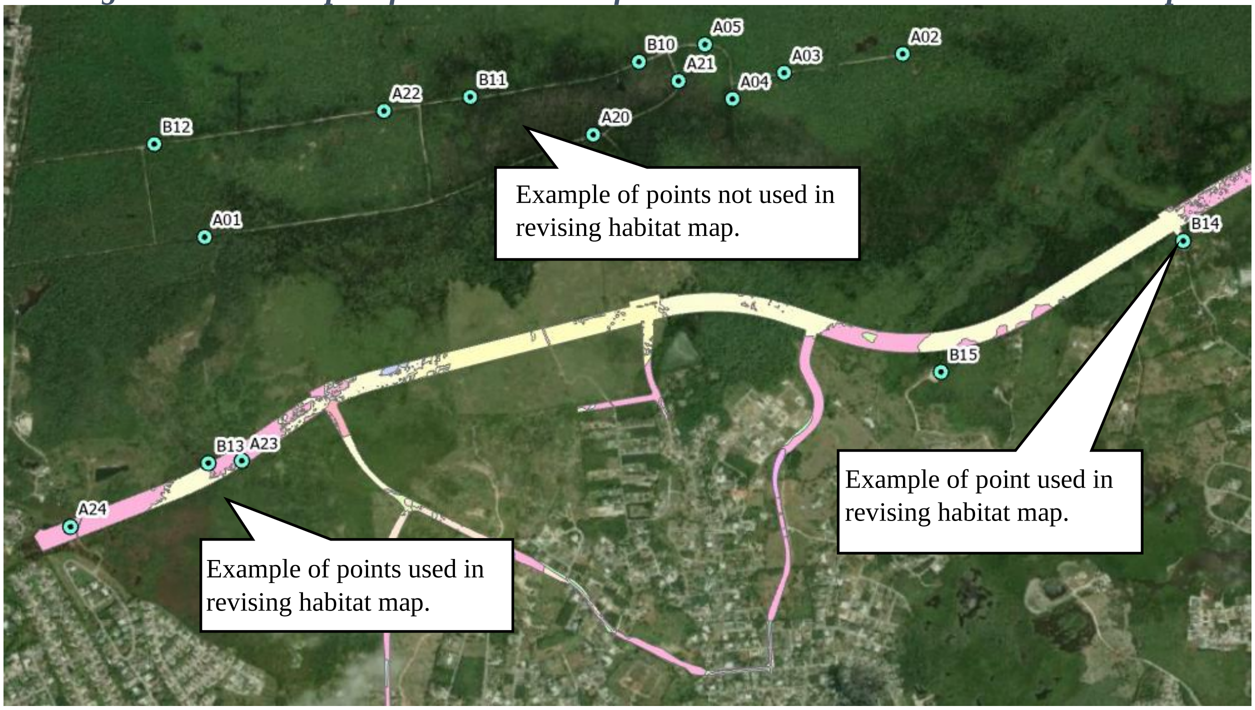
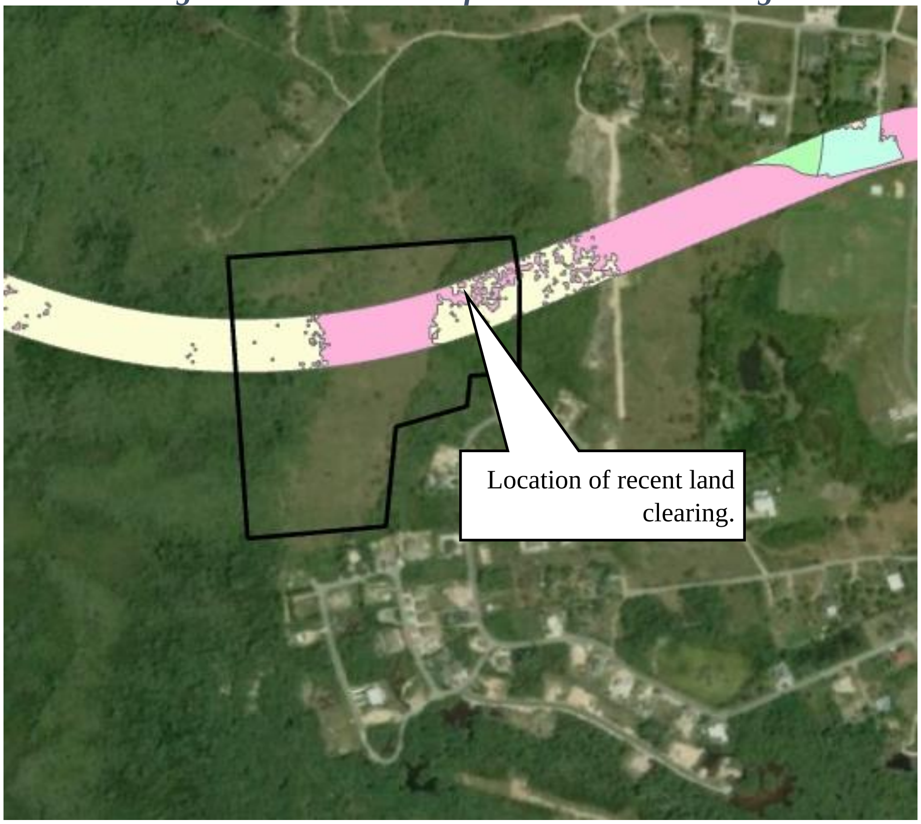


Figure 13-5: Location of Recent Land Clearing



13.3.4 Mitigation Estimation

Functional loss is a value that is required to be offset through compensatory mitigation. Compensatory mitigation can be met through creation, restoration, enhancement or preservation. Similar to the methods described in **Section 13.3.2.1: Functional Assessment of Habitats**, the functional value of the proposed mitigation must be calculated by determining a mitigation delta. The mitigation delta is the difference between the current functional value of the proposed mitigation area and the mitigation functional value (i.e., increase in ecological function resulting from the proposed mitigation).

13.3.4.1 Creation, Restoration, and Enhancement

For creation, restoration, and enhancement, a time lag and risk factor must be calculated. The time lag is the period of time, in years, between when the functions are lost at an impact site and when those functions are replaced by mitigation. Based on the time lag, a time lag factor (T-factor) is calculated (**Table 13-2**). The risk factor considers the uncertainty that the proposed conditions will be achieved, resulting in a reduction in the ecological value of the mitigation area. The risk factor is scored on a scale from 1 (for no or low risk) to 3 (high risk), on quarter-point (0.25) increments. A score of one would most often be applied to mitigation conducted in an ecologically viable landscape and deemed successful or clearly trending towards success prior to impacts, whereas a score of three would indicate an extremely low likelihood of success based on a number of ecological factors. The functional gain of a proposed mitigation area relative to time lag and risk is called the relative functional gain and is calculated by dividing the mitigation delta by the product of the T-factor multiplied by the risk factor.

Table 13-2: Time Lag and T-factor

Time Lag (Years)	T-factor
≤ 1	1
2	1.03
3	1.07
4	1.10
5	1.14
6 – 10	1.25
11 – 15	1.46
16 – 20	1.68
21 – 25	1.92
26 – 30	2.18
31 – 35	2.45
36 – 40	2.73
41 – 45	3.03
46 – 50	3.34
51 – 55	3.65
>55	3.91

13.3.4.2 Preservation

The gain in ecological value from preservation is determined by multiplying the mitigation delta by a preservation adjustment factor. The preservation adjustment factor is scored on a scale from 0 (no preservation value) to 1 (optimal preservation value), on one-tenth increments. The score is based on:

- the extent the preserved area will promote natural ecological conditions;
- the ecological and hydrological relationship between wetlands, other surface waters, and uplands to be preserved;
- the scarcity of the habitat provided by the proposed preservation area and the level of use by listed species;
- the proximity of the preserved area to areas of national, state, or regional ecological significance, and whether the areas to be preserved include corridors between these habitats; and
- the extent and likelihood of potential adverse impacts if the assessment area were not preserved.

13.3.5 Qualitative Assessment

The qualitative assessment for terrestrial ecology is based on the UK Department for Transport's "Transport Analysis Guidance Unit A3: Environmental Impact Appraisal" (WebTAG). The most applicable category for terrestrial ecology impacts is "Impacts to Biodiversity." This qualitative assessment follows Section 9 of WebTAG.

There are three steps in the WebTAG qualitative assessment. The first step is to determine the importance (or value) of features, which includes very high, high, medium, and low. The second step is to determine the magnitude of impact (positive or negative), which includes major, moderate, and minor and also negligible. The third step is to determine the overall assessment score based on the results of Steps 1 and 2. As shown in **Table 13-3**, the assessment scores are based on the magnitude of impact and the importance of the water environment feature and can include large adverse, moderate adverse, slight adverse, and neutral. More information on the qualitative assessment methodology for terrestrial ecology can be found in the **Appendix E - Shortlist [Alternatives] Evaluation: Attachment F - Terrestrial Ecology – Assessment of Alternatives**.

Table 13-3: Overall Assessment Score Matrix

Magnitude of impact	Biodiversity and earth heritage value				
	Very high	High	Medium	Low	Very Low
Major Negative	Large adverse	Large adverse	Moderate adverse	Slight adverse	Neutral
Intermediate Negative	Large adverse	Large adverse	Moderate adverse	Slight adverse	Neutral
Minor Negative	Slight adverse	Slight adverse	Slight adverse	Slight adverse	Neutral
Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
Positive	Large beneficial	Large beneficial	Moderate beneficial	Slight beneficial	Neutral

Source: TAG Unit A3, Environmental Impact Appraisal, Table 12, May 2023

13.3.6 Monetary Assessment

The monetary valuation of ecosystem services is based on the Cayman Islands Ecosystem Accounting document (**Appendix E - Shortlist [Alternatives] Evaluation: Attachment F - Terrestrial Ecology – Assessment of Alternatives**). Based on the 2020 Cayman Islands Ecosystem Accounting, there are currently monetised values for Fisheries, Agriculture, Carbon Sequestration, Coastal Protection, Tourism, and Amenity Value. (Economics for the Environment Consultancy Ltd (EFTEC) & Joint Nature Conservation Committee, 2022)

The 2020 Cayman Islands Ecosystem Accounting is not all-inclusive of ecosystem services provided on Grand Cayman. Therefore, quantitative and qualitative review of terrestrial ecology has also been provided as part of the EIA.

13.4 Baseline Conditions

The diverse habitats of Grand Cayman include a variety of upland, wetland, and coastal habitats. Upland habitats 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 sedges, 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. The following Baseline Conditions will be presented starting at a larger scale that considers the island of Grand Cayman and the EIA Study Area followed by a discussion of the Baseline Conditions within the footprint of the Proposed Project. It is important to note that the Baseline Conditions of the EIA Study Area are provided for context. The Proposed Project has been developed to avoid resources such as the Mastic Reserve and Trail, NCA Protected Lands, NCA Marine Protected Areas, and NT Lands. Furthermore, the Proposed Project has been determined not to result in impacts to marine resources.

13.4.1 Baseline Conditions: Grand Cayman and the EIA Study Area

13.4.1.1 Protected Areas

Protected ecological resources identified within, adjacent to, or in the vicinity of the EIA Study Area included the NT sites in the CMW and the Mastic Reserve, four NCA protected sites, NCA marine protected resources, and marine turtle nesting beaches and critical habitat. **Figures 13-6** and **13-7**, on the following pages, show the location of the Proposed Project in relation to the terrestrial protected and marine protected areas, respectively. Following **Figure 13-7**, **Table 13-4** provides a list of the NCA Marine Protected Areas shown in this figure. In addition, **Table 13-5** provides more information about the protected areas described in this section and shown in **Figures 13-6** and **13-7**.

Figure 13-6: Map of Terrestrial Protected Areas

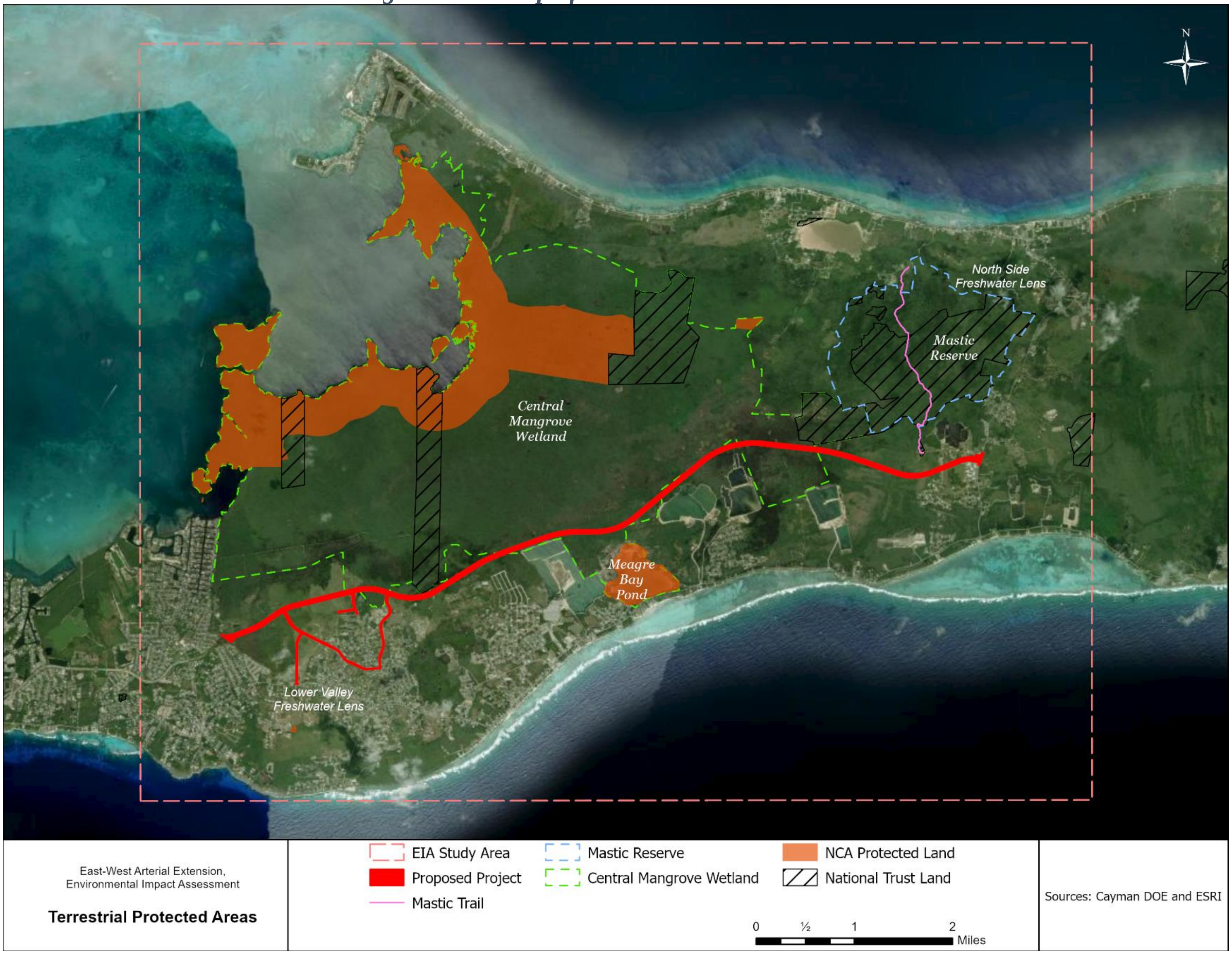


Figure 13-7: Map of Marine Protected Areas

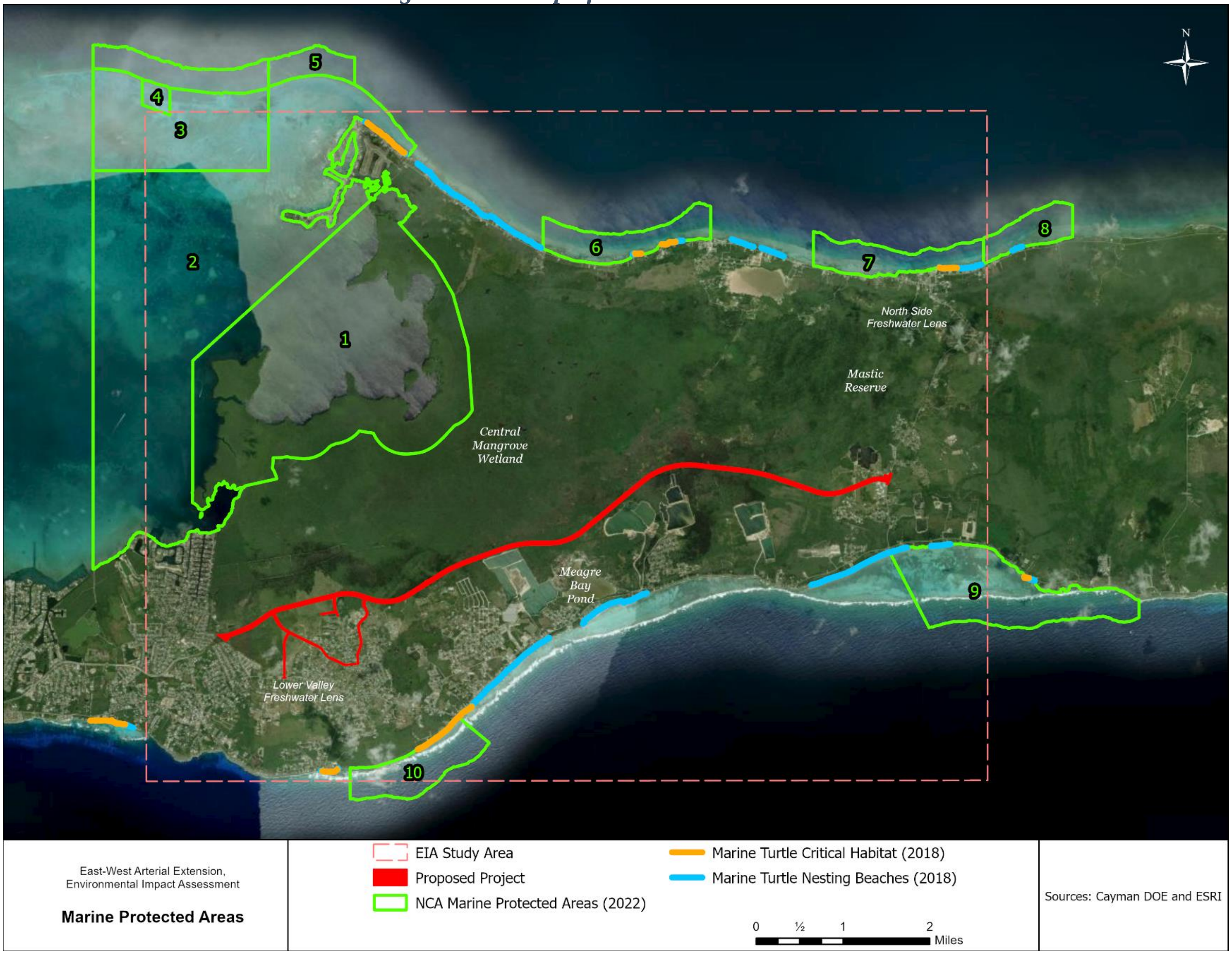


Table 13-4: NCA Marine Protected Areas in Figure 13-4

Map ID	Name
1	Little Sound Environmental Zone
2	North Sound Marine Reserve
3	Stingray City Sandbar Wildlife Interaction Zone
4	Stingray City Sandbar No-Diving Overlay Zone
5	Rum Point Channel East No-Diving Overlay Zone
6	North Side West No-Diving Overlay Zone
7	North Side East No-Diving Overlay Zone
8	Queen's Highway West Marine Reserve
9	Frank Sound East Marine Reserve
10	Bodden Town West Marine Reserve

Table 13-5: Protected Sites Within, Adjacent to, or in the Vicinity of the Study Area

Resource Name	Governing Entity	Description
Terrestrial Protected Areas (Figure 13-6)		
CMW	NT and NCA	The CMW 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	NT	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	Small island located south of the Little Sound Environmental Zone
Meagre Bay Pond and Animal Sanctuary	NCA (has an adopted Management Plan)	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 Protected Areas (Figure 13-7)		
Marine Turtle Critical Habitat	NCA	Designated Marine Turtle Critical Habitat Protection Zones
Marine Turtle Nesting Beaches	NCA	Designated Marine Turtle Nesting Beaches

Resource Name	Governing Entity	Description
Marine Protected Areas (Figure 13-7)		
Little Sound Environmental Zone	NCA	Large, protected swath of the CMW that encircles the Little Sound. *Meets criteria for designation as a Ramsar site**
North Sound Marine Reserve	NCA	A 13,838 ac (5,600 ha) semi-enclosed, shallow lagoon, historically fringed with mangrove wetland to the west, south, and east, and with an exposed fringing reef to the north.
Stingray City Sandbar Wildlife Interaction Zone &No-Diving Overlay Zone	NCA	A designated Wildlife Interaction Zone (WIZ) in the North Sound Marine Reserve. Allows for interaction with stingrays.
Rum Point Channel East No-Diving Zone	NCA	Marine Protected Area
North Side West & East No-Diving Zone	NCA	Marine Protected Area
Queen's Highway West Marine Reserve	NCA	Marine Protected Area
Frank Sound East Marine Reserve	NCA	Marine Protected Area
Bodden Town West Marine Reserve	NCA	Marine Protected Area

*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. There are currently Proposed Ramsar Sites located within the EIA Study Area, however the only Designated Ramsar Site within the Cayman Islands as of October 2024 is Booby Pond and Rookery on Little Cayman (Ramsar Sites | JNCC - Adviser to Government on Nature Conservation).

Central Mangrove Wetland (CMW)

The CMW is a habitat that is unique and important to Grand Cayman. The CMW is 8,655 ac (3,503 ha) in size and comprises approximately 30% of Grand Cayman, making it the largest contiguous mangrove wetland in the Caribbean. Many 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 CMW provides carbon storage, local climate regulation, water flow regulation, water quality improvement, habitats for wetland dependent species, and coastal protection. The CMW 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 CMW; consequently, effects to the CMW will also affect the North Sound ecosystem.

Little Sound Environmental Zone

The Little Sound Environmental Zone is a large, protected swath of the CMW that encircles the Little Sound. Adjacent to the Little Sound is the North Sound, a 3,838 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. Both the Little Sound and North Sound provide habitat and nurseries for fish and support clear water diving, and many livelihoods on Grand Cayman.

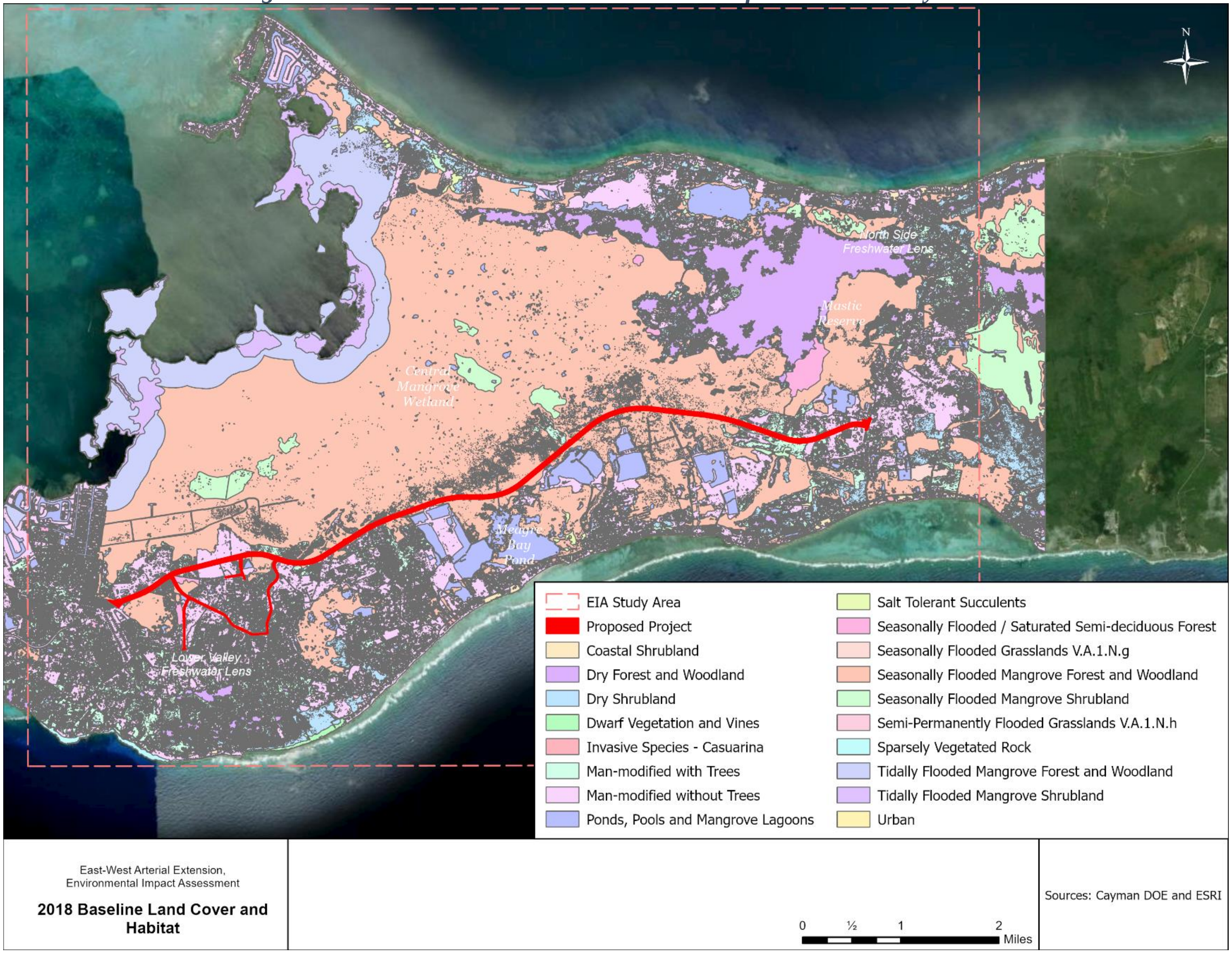
Mastic Forest

The Mastic Forest is approximately 1,329 ac (538 ha) in size and is the largest contiguous evergreen woodland remaining on Grand Cayman. It represents one of the last remaining examples of the Caribbean subtropical, semi-deciduous dry forest. The forest is largely untouched, other than selective logging and small-scale agriculture that occurred in the past. 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.

13.4.1.2 Grand Cayman Landcover and Habitat (2018)

A number of habitats, outlined in the 2009 NBAP and shown in **Figure 13-8**, comprise the ecosystems on Grand Cayman. The island houses coastal, wetland, and upland ecosystems that play an important role in providing ecosystem services and supporting native wildlife. The ecosystems are interconnected hydrologically and often share in the species that depend on them. Major ecosystems that are relatively untouched by human activity include wetland ecosystems and upland ecosystems. Following is a description of the broad habitat types (uplands and wetlands) found on Grand Cayman. **Appendix K.2: Terrestrial Habitat Descriptions** contains the classifications and descriptions of specific habitats identified within the EIA Study Area based on the Vegetation Classification for the Cayman Islands (Burton, 2007). Additional habitat subclassifications were added based on the desktop and field reviews.

Figure 13-8: Baseline Landcover and Habitat of EWA EIA Study Area



Upland Ecosystems

The predominant upland ecosystems on the island that are untouched by humans include dry forest and woodland, dry shrubland, and the Mastic Reserve. Dry forests and woodlands generally occur at least 5.9 ft (1.8 m) above the groundwater table and are typically dominated by the red birch (*Bursera simaruba*). Dry shrublands are typically found on the eastern portion of the island and are dominated by Cayman agave (*Agave caymanensis*) and cocoplum (*Chrysobalanus icaco*). Dry forests, followed closely by dry shrubland, are the most biodiverse upland ecosystems on Grand Cayman. These habitats include the valuable assemblies of rare and endemic plants and trees, as well as a diversity of resident and migratory birds.

The Mastic Reserve is the oldest ecosystem on Grand Cayman. Comprised of subtropical, semi-deciduous dry forest, this part of the island is home to many endemic flora and fauna. The Mastic Reserve is recognized as an Important Bird Area, and provides habitat to numerous endemic species, including ten plant species, four reptile species, and five butterfly species (Bradley et al., 2004).

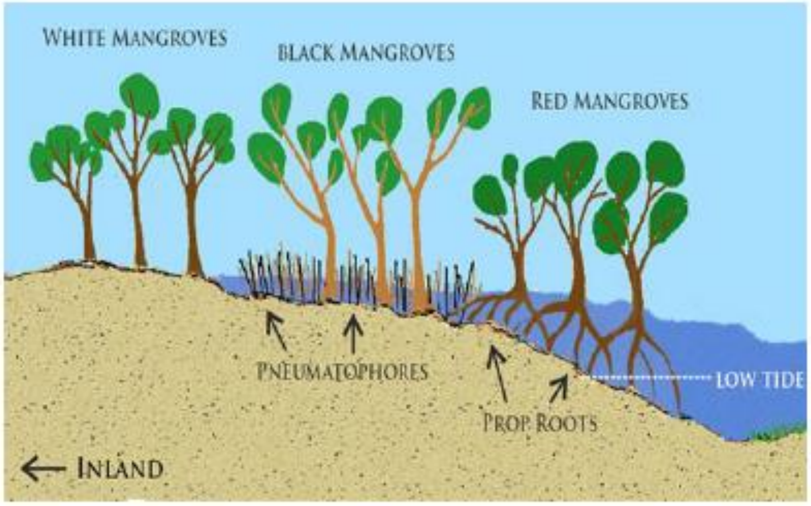
The Mastic Reserve is connected to the other ecosystems on Grand Cayman in many ways, both by providing habitat to some of the same species and via hydrological connection. The Mastic Reserve absorbs rainfall and slowly releases it, helping to regulate the water flow on the island. Some of that water soaks into the soil and recharges the groundwater, making it an essential part of supplying the island with freshwater. It also includes some pools and seasonal ponds, which support aquatic life.

Wetland Ecosystems

Mangrove wetlands provide Grand Cayman myriad ecosystem services, like protecting the coast from storms, waves, and floods; inhibiting coastal erosion; carbon sequestration; water filtration; and providing important habitat to many species like the Grand Cayman parrot (*Amazona leucocephala caymanensis*). The CMW and Meagre Bay Pond are both part of the mangrove wetland ecosystem on the island. The CMW is one of the largest contiguous wetlands in the Caribbean.

Ideal conditions for mangroves include low wave energy, brackish water, fine soil sediment, and waterlogged soil. On Grand Cayman, mangroves typically grow on peat, laid down by mangroves themselves. The unique root systems of the red mangrove (aerial prop roots) and black mangrove (pneumatophores) slow the flow of the tides and encourage mud and silt deposition. Water salinity and hydroperiod (i.e., the depth, duration, and frequency of tides) affect the composition of mangroves in wetlands like the CMW. Any major disturbance to one or more of these factors is likely to alter the species composition, since red, black, and white mangroves each prefer different depths of inundation and water salinity levels (**Figure 13-9**). Hurricane events can also strongly influence mangrove communities on Grand Cayman.

Figure 13-9: Mangrove Succession



Source: NCC Species Conservation Plan for Mangroves, National Conservation Law, Section 17 – Mangrove Trimming Guidelines www.doe.ky

The CMW is an integral part of the water flow system on Grand Cayman. Water migrates, primarily as sheet flows, from the southern coast, across the CMW, and into the North Sound. The mangrove system filters the surface water and shallow ground water that flows through it, absorbing excess nutrients, conditioning the surface ground and ground water, which is essential to the North Sound food chain. In addition, the CMW has an important role in the evapotranspiration/precipitation cycle of Grand Cayman. An estimated 40% of the rainfall in western districts of the island is believed to be due to evapotranspiration in the CMW (Bradley et al, 2004).

Meagre Bay Pond is part of the flow pattern between the southern shore of the island, the CMW, and North Sound. Meagre Bay Pond has a buffer of mangroves around it and provides habitat for over 104 different species of migratory birds and plenty of other wildlife (www.eBird.org). In times of heavy rain, Meagre Bay Pond contributes to the south-to-north sheet flow through the CMW. Quarry and residential development adjacent to Meagre Bay Pond threaten Meagre Bay Pond's hydrology and its connection to the CMW sheet flow system.

13.4.1.3 Existing Developed Conditions and Trends

Five districts make up Grand Cayman: West Bay, George Town, Bodden Town, North Side, and East End, with Owen Roberts International Airport and the George Town 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. Farther east, Bodden Town, North Side, and East End are primarily residential with some minor retail and community facilities interspersed along the existing roadways. Bodden Town is currently the fastest growing district, almost tripling in population size since the turn of the 21st century, while the North Side and East End remain relatively sparsely populated. The EIA study area encompasses both the Bodden Town and North Side Districts with the area required for the Proposed Project being primarily located within the Bodden Town District (Economic and Statistics Office, 2022).

The overall EIA study area consists of residential, commercial, agricultural, industrial, and natural sites. Portions of the CMW also extend into the EIA study area. Several active mine quarries sit within the EIA study area. Recent aerial photographs, as well as Normalized Difference Vegetation Index and Colour Infrared (CIR) data derived from satellite imagery, provide a general overview of existing vegetative conditions within the EIA study area. The CMW and developed areas within the EIA study area are visually apparent. A distinct area marked by low density mangrove vegetation occurs along the southern boundary of the CMW, from Bodden Town to North Side as shown in **Figures 13-2, 13-6,** and **13-7.** This low-density vegetation area appears to be comprised of a mix of mangroves, open water, bare ground (peat), and man-modified areas. **Figures 13-2** (in **Section 13.2.2** of this chapter) depicts the 2023 True Colour Aerial with an example area of low-density mangrove habitat. Review of the aerial imagery shows cleared access paths/roads and canals extending through this area. Vegetation density also appears to be lower throughout this area when compared to the CMW areas farther north.

Additional aerial imagery analysis techniques were used to evaluate the area of low-density mangroves during the Assessment of Alternatives, including investigating CIR and NDVI, both common methodologies for assessing aerial depictions of vegetated areas. A full description of this assessment can be found in the **Appendix E - Shortlist [Alternatives] Evaluation: Attachment F - Terrestrial Ecology – Assessment of Alternatives**.

13.4.1.4 Important Species Habitat

National Biodiversity Action Plan (NBAP)

Grand Cayman is home to a variety of species, including endemic flora and fauna, species protected under the 2013 NCA, and species included on the International Union for Conservation of Nature's (IUCN) Red List. The Cayman Islands NBAP 2009 provides lists of key species supported by the variety of habitats on the Cayman Islands. In addition, Species Action Plans (SAPs) have been developed to help preserve species of special interest. The EWA EIA Study Area primarily encompasses terrestrial habitat (including mangrove habitat, which is classified as a "coastal habitat" under the NBAP 2009; see **Section 13.4.2.1: Habitat Within the Footprint of the Proposed Project: Terrestrial Habitat Descriptions** and **Section 13.4.2.3: Habitat Quality/Functionality** for a list of habitat types found within the footprint of the Proposed Project). SAPs for terrestrial animal species found on Grand Cayman in habitats within the EIA Study Area are described in **Table 13-6.** Detailed lists of key species per habitat type and SAPs of relevant animal species can be found in **Appendix K.3 – List of Species (NBAP)**.

Table 13-6: Terrestrial Animal Species with SAPs

Scientific name	Common name	Habitat	Status / Protection
Invertebrates			
Brephidium exilis thompsoni	Cayman Pygmy Blue butterfly	• Salt-Tolerant Succulents • Ponds, Pools, and Mangrove Lagoons	NCA* (Part 1)
Cardisoma guanhumi	White Land Crab	• Roads • Urban and Man-Modified • Mangrove	NCA (Part 2)

Scientific name	Common name	Habitat	Status / Protection
Freshwater Fish			
Limia caymanensis & Gambusia xanthosoma	Mosquito fish	• Ponds, Pools, and Mangrove Lagoons • Mangrove	IUCN Red List – Near Threatened (*Limia caymanensis*) IUCN Red List – Endangered (*Gambusia xanthosoma*) NCA (Part 2)
Reptiles			
Cyclura lewisi	Grand Cayman Blue iguana	• Dry Shrubland • Roads	IUCN Red List – Endangered NCA (part 1)
Birds			
Phaethon lepturus	White-tailed tropicbird	• Caves	NCA (part 1)
Sula sula	Red-footed booby	• Ponds, Pools, and Mangrove Lagoons • Dry shrubland • Forest and Woodland • Mangrove	NCA (part 1)
Dendrocygna arborea	West Indian Whistling-duck	• Salt-Tolerant Succulents • Ponds, Pools, and Mangrove Lagoons • Farm and Grassland • Urban and Man-Modified • Mangrove	IUCN Red List – Near Threatened NCA (part 1)
Amazona leucocephala	Cayman parrot	• Dry Shrubland • Dry Forest • Forest and Woodland • Farm and Grassland • Mangrove • Urban and Man-Modified	IUCN Red List – Near Threatened NCA (part 1)
Dendroica vitellina	Vitelline warbler	• Dry Shrubland • Dry Forest • Urban and Man-Modified	IUCN Red List – Near Threatened NCA (part 1)
Mammals			
Chiroptera	Bats	• Ponds, Pools, and Mangrove Lagoons • Dry Shrubland • Dry Forest • Forest and Woodland • Caves • Farm and Grassland • Urban and Man-Modified • Roads • Mangrove	NCA (Part 1)

Source: NBAP 2009

**Animals protected under NCA Schedule 1 Part 1 are protected at all times. Animals protected under NCA Schedule 1 Part 2 are species which may be hunted or collected in accordance with regulations or a conservation plan, if any.*

Species encountered during the field investigation were noted, and the presence, or estimated presence based on habitat type were included within the determination of the UMAM quality and function results (**Appendix K.1: UMAM Mapping and Sheets**). No formal species surveys were conducted as part of the EWA Extension EIA.

Geospatial Data

Geospatial data for species on Grand Cayman is limited. Data provided by the DoE regarding important species habitat included: Cayman parrot nesting habitat, Cuban white-shouldered bat (*Phyllops falcatus*), tea banker (*Pectis caymanensis*), Cayman pygmy blue butterfly, marine turtle nesting habitat (sea turtles on Grand Cayman include *Caretta caretta*, *Chelonia mydas*, *Dermochelys coriacea*, *Eretmochelys imbricata*, and *Lepidochelys kempii*), marine turtle critical habitat (includes same as previous), white tailed tropicbird (*Phaethon lepturus*), and *Pisonia margaratae* (an endemic woody shrub). Additional data on 2014 parrot density was provided by DoE.

The geospatial data provided represents the only habitat data formally delineated within the EWA EIA Study Area.

A summary of each species habitat is as follows, per the Cayman NBAP (2009):

- Marine turtle nesting habitat and marine turtle critical habitat – These habitats refer to the terrestrial areas used during the portion of the sea turtle lifecycle spent on and near land. Female sea turtles create nests on shore, and many species use feeding grounds near shore (seagrass beds and coral reefs) (NBAP, 2009).
- Mint – This endemic plant species is a woody vine that grows in the canopy of forest and woodland habitats.
- Parrot nesting habitat – On Grand Cayman parrots breed in cavities in black mangroves, as well as in cavities in dry forest tree species. Breeding season for birds on Grand Cayman is identified as April through late June (Cayman Turtle Centre, 2021).
- *Pisonia margaratae* – This woody shrub is found in terrestrial habitats, typically the understory of forest and woodlands, though it is also known to be found adjacent to roads (NBAP, 2009)
- Pygmy blue butterfly – The butterfly depends on habitats of salt-tolerant succulents during all life-cycle phases. It is also found in pools, ponds, and mangrove lagoons. Some of its habitats have been reduced to areas of a few square yards/metres.
- Tea banker – This coastal perennial herb typically grows close to the coast, in sand and gravel. It may also be found in beachside cemeteries and is subject to habitat fragmentation due to human activity (NBAP, 2009)
- White-shouldered bat – The white shouldered bat uses the mature dry forest habitat on Grand Cayman.
- White tailed tropicbird – This bird uses cliff and cave habitats during breeding season, laying just one egg in a rock crevice. These birds have been observed on the coastal bluff east of Bodden Town in Grand Cayman.

Additionally, the parrot density data is based on parrot sightings and is not limited to solely nesting habitat. Parrots may forage outside of their nesting habitat, accounting for observed parrots outside of the delineated nesting habitat. Generally, parrot habitat contains mangrove, coastal shrubland, dry shrubland, dry forest, farm and grassland, and urban and man-modified areas. The density data received from DoE covers areas of no parrot sightings to areas of up to three parrot sightings per ha. The estimated number of parrots on Grand Cayman may be as low as 1,400 and as abundant as 7,500 or more, as estimates vary by source and time frame. According to "Important Bird Areas in the Caribbean – Cayman Islands", Grand Cayman was home to approximately 1,408-1,935 parrots in 1995. Per Haakonsson et al. (2017), Grand Cayman had an estimated parrot population size of 6,395 (+/- 1,202) parrots in 2014. The provided parrot density data is from 2014; therefore, it is estimated to be based on a parrot population size of approximately 6,395 per Haakonsson et al. (2017).

13.4.2 Baseline Conditions: Proposed Project

The following discusses the Baseline Conditions within the estimated LOD of the Proposed Project including habitat types (including important species habitat), mangrove density, and habitat quality/functionality. See Section 13.5 for more information on the estimated LOD of the Proposed Project.

13.4.2.1 Habitat Within the Footprint of the Proposed Project

The habitats and land uses found within the footprint of the Proposed Project range from natural upland and wetland ecosystems to heavily man-modified land uses. **Appendix K.2: Terrestrial Habitat Descriptions** contains descriptions of these habitats and land uses as documented during the Assessment of Alternatives with photographs from both the 2023 and 2024 field evaluations. **Table 13-7** lists the habitats and their extents (acres/hectares) within the Proposed Project. The revised habitat map for the Proposed Project is included in **Appendix K.4: Proposed Project Habitats and Land Uses Mapping**.

Table 13-7: Habitats Within the Footprint of the Proposed Project

Habitat	Acres (ac)	Hectares (ha)
Man-modified Land Uses		
Commercial	2.09	0.85
Institutional	0.10	0.04
Man-made Pond	0.32	0.13
Man-modified with Trees	32.70	13.23
Man-modified without Trees	34.77	14.07
Pasture	15.43	6.24
Residential	2.30	0.93
Roads	2.37	0.96
Total	**90.08**	**36.45**
Upland Habitats		
Dry Forest and Woodland	3.61	1.46
Invasive Species - Casuarina	0.33	0.13
Palm Hammock	1.4	0.57
Total	5.34	2.16
Wetland Habitats		
Ponds, Pools and Mangrove Lagoons	0.35	0.14
Seasonally Flooded Mangrove Forest and Woodland	148.29	60.01
Seasonally Flooded / Saturated Semi-deciduous Forest	1.6	0.65
Total	**150.24**	**60.8**
Grand Total All		
Total	**245.66**	**99.41**

13.4.2.2 Important Species Habitat Within the Footprint of the Proposed Project

Based upon review of the NBAP, **Table 13-7** lists the key species per habitat type and SAPs of relevant animal species within the identified Proposed Project habitats. The only available geospatial data (**Section 13.4.1.4: Important Species Habitat**) within the Proposed Project includes the Cayman Parrot nesting habitat and 2014 density.

Based upon correspondence with the DoE, the primary species of concern for the Proposed Project include the Cayman Parrot and White Land Crab.

13.4.2.3 Habitat Quality/Functionality

Table 13-8 summarizes the UMAM scores for each of the habitat types and man-modified land uses within the Proposed Project. A total of 92 field verification points was collected in 2023 and 2024 encompassing the Assessment of Alternatives and the Proposed Project, and 69 were for habitat types found within the Proposed Project. The values in this table represent an average score amongst field verification points collected for each respective habitat/land use found within the Proposed Project. To provide context to the averages, the table also includes the number of field verification points that were collected for each habitat type and land use and the range in UMAM scores. As previously described, some locations in the Proposed Project were inaccessible and limited the scope of field verification point collection. A map of average UMAM scores for these habitats and land uses across the Proposed Project is provided in **Appendix K.1: UMAM Mapping and Sheets**.

Table 13-8: UMAM Scores for Habitats/Land Uses Within the Footprint of the Proposed Project

Habitat/Land Use	Number of Field Data Points Collected	Range in UMAM Scores	Average UMAM Scores (0-1)
Dry Forest and Woodland	6	0.55 – 0.75	0.63
Invasive Species - *Casuarina*	3	0.30 – 0.45	0.38
Man-modified with Trees	5	0.35 – 0.65	0.54
Man-modified without Trees	10	0.20 – 0.65	0.43
Palm Hammock	1	0.70	0.70
Pasture	1	0.45	0.45
Ponds, Pools, and Mangrove Lagoons	10	0.53 – 0.87	0.66
Seasonally Flooded Mangrove Forest and Woodland	32	0.50 – 0.90	0.70
Seasonally Flooded / Saturated Semi-deciduous Forest	1	0.57	0.57

As previously described, the UMAM scores range from zero to one with zero indicating conditions that are insufficient to provide the natural functions of the particular habitat (e.g., a road). A score of 0.40 indicates a minimal level of support to habitat functions. A score of 0.70 indicates that conditions are less than optimal, but sufficient to maintain most habitat functions. A score of one indicates conditions are optimal and fully support habitat functions. This scoring of functions was used as a proxy for habitat value. In this use a score of zero would have no habitat value (e.g., road) and a score of one would indicate pristine habitat.

The results of the UMAM analysis show that in general the average functional value of habitats and land use range from minimal (0.38 for Invasive Species – *Casuarina*) to moderate (0.70 for seasonally flooded mangrove forest and wood land and palm hammock). The man-modified land uses are closer to the minimal range of habitat values and the natural habitats are closer to moderate habitat value. It is important to note that the value of 1.0, pristine habitat, is usually not given as it indicates perfect conditions which are hard to find even in areas undisturbed by human influence. Based on the location of the Proposed Project, the field verification points are on the edge of where the CMW abuts man-made development. This is likely having an edge effect where habitats closer to development experience environmental stressors (e.g., pollution, untreated water run-off, decreased shading and increased temperature, etc.) from the developed land uses not found in locations further from development and thus result in habitat degradation to varying degrees.

The UMAM data was collected to provide a planning-level approximation of the mitigation that would be required to offset functional loss of habitat and, therefore, achieve No Net Loss of Biodiversity. There was variability of UMAM scores among habitat types and also within habitat types that highlights the need to collect additional, site-specific data for habitat that will be impacted as well as specific sites that will be enhanced or remediated. Seasonally Flooded Mangrove Forest and Woodland represent the greatest area of impact; therefore, emphasis was placed on collecting more field verification points in mangrove habitats than the other habitats to better characterize the potential functional loss. This data skew resulted in certain habitats with fewer field verification points (e.g., palm hammock with one field verification point); however, the results still provide an applicable estimate of habitat values.

13.4.2.4 Mangrove Density

An area of apparent low mangrove density was observed within the EIA Study Area. UMAM scores of mangrove field verification points (ponds, pools and mangrove lagoons; seasonally flooded mangrove forest; and seasonally flooded mangrove shrubland) taken within or adjacent to the "low density area" were compared to UMAM scores of mangrove field verification points taken outside of the "low density area" – **Table 13-9**. The range in UMAM scores across these three location categories are similar. The highest UMAM score (0.9) was recorded within the "low density area." These results indicate that the "low density area" does not necessarily equate to a lower functional score than the higher density areas. Based on the results of this comparison, the habitat class of seasonally flooded mangrove forest (low density) was incorporated into the seasonally flooded mangrove forest and woodland habitat, as shown in **Table 13-7** and **13-8**.

Table 13-9: Mangrove UMAM Comparison

Location	Number of Field Data Points Collected	Range in UMAM Scores	Average UMAM Score
Adjacent to Low Density Mangrove Area	9	0.63 – 0.80	0.72
In Low Density Mangrove Area	21	0.53 – 0.90	0.69
High Density Mangrove Area	14	0.50 – 0.77	0.63

13.5 Project Impacts

This section describes the potential impacts to terrestrial ecology resources that are estimated to occur as a result of the Proposed Project, either directly or indirectly through construction or operations. The Proposed Project is described in **Chapter 6: Proposed Project – Engineering Features**. **Chapter 15: Summary of Direct, Indirect, Secondary/Induced and Cumulative Effects** includes Secondary, Induced, and Cumulative impacts.

For this specific discipline, the entire mainline corridor width of 220 ft (67 m) was used to calculate potential impacts along the mainline of the Proposed Project and a width of 41 ft (12.5 m) was used for the roadway sections that are included for the Will T Connector. The estimated LOD areas surrounding the proposed intersections and access points, as well as locations with wider needs for cut or fill slopes were also included in the impact calculations.

13.5.1 Direct Impacts

13.5.1.1 Terrestrial Habitat Impacts

Estimated direct habitat impacts were quantified for the Proposed Project. Direct impacts are those that result from the project activities and result in a total/100% loss of the resource being evaluated. These direct habitat impacts were quantified based on the entire corridor width as a worst-case scenario. Details regarding the Proposed Project corridor widths are within **Chapter 6: Proposed Project – Engineering Features**. The Future No-Build condition is assumed to have no direct impact on habitats.

The area of direct impact totals 245.66 ac, or 99.41 ha, and is made up of a variety of man-modified land uses in addition to upland and wetland habitats. **Table 13-10** provides a summary of direct impacts by land use and habitat type and associated functional loss (as applicable). Functional loss is the loss of ecological function within a given assessment area resulting from a proposed action. It can be a total loss (e.g., removal of habitat) or partial loss (e.g., loss or reduction of some, but not all, of its ecological function). For this analysis, the functional loss was assumed as total loss. Functional loss is calculated by multiplying the UMAM score by the acres (or hectares) of impact of a given assessment area. Overall, the Proposed Project will result in a loss of 147.87 functional units (UMAM score times acres of impact). These functional units can be used to determine the amount of compensatory mitigation required to offset the loss of function resulting from the Proposed Project. This will be described in further detail in **Section 13.6.1: Mitigating Terrestrial Habitat Functional Loss** of this chapter.

Table 13-10: Direct Impacts Resulting from the Proposed Project

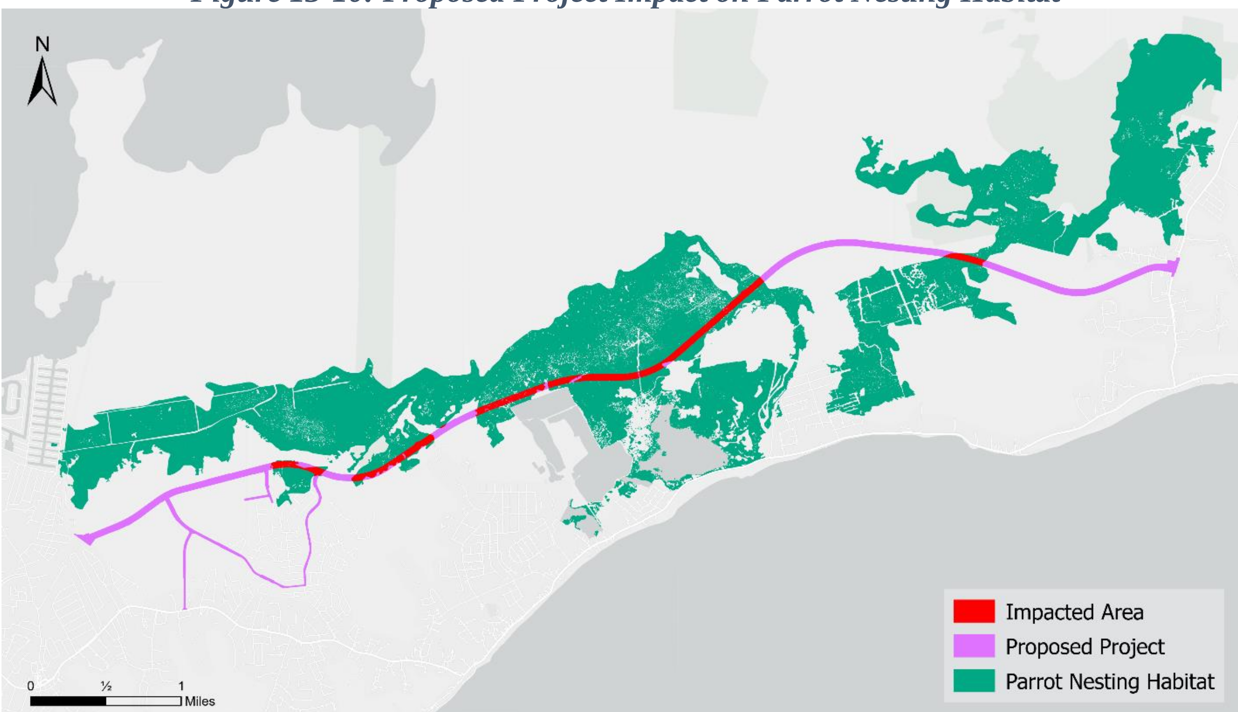
Habitat	Direct Impacts		Functional Value (UMAM)			Functional Loss (Direct Impact) (UMAM units – Acres x Functional Value)		
	Hectares	Acres	Minimum	Maximum	Average	Minimum	Maximum	Average
Man-modified Land Uses								
Commercial	0.85	2.09	N/A			0.00	0.00	0.00
Institutional	0.04	0.10						
Man-made Pond	0.13	0.32						
Man-modified with Trees	13.23	32.7	0.35	0.65	0.54	11.45	21.26	17.66
Man-modified without Trees	14.07	34.77	0.20	0.65	0.43	6.95	22.60	14.95
Pasture	6.24	15.43	0.45	0.45	0.45	6.94	6.94	6.94
Residential	0.93	2.30	N/A			0.00	0.00	0.00
Roads	0.96	2.37						
Total	**36.45**	**90.08**	**N/A**			**25.34**	**50.80**	**39.55**
Upland Habitats								
Dry Forest and Woodland	1.46	3.61	0.55	0.75	0.63	1.99	2.71	2.27
Invasive Species - Casuarina	0.13	0.33	0.30	0.45	0.38	0.10	0.15	0.13
Palm Hammock	0.57	1.4	0.70	0.70	0.70	0.98	0.98	0.98
Total	**2.16**	**5.34**	**N/A**			**3.07**	**3.84**	**3.38**
Wetland Habitats								
Ponds, Pools and Mangrove Lagoons	0.14	0.35	0.53	0.87	0.66	0.19	0.30	0.23
Seasonally Flooded / Saturated Semi-deciduous Forest	0.65	1.60	0.57	0.57	0.57	0.91	0.91	0.91
Seasonally Flooded Mangrove Forest and Woodland	60.01	148.29	0.50	0.90	0.70	74.15	133.46	103.80
Total	**60.8**	**150.24**	**N/A**			**75.25**	**134.67**	**104.94**
Grand Total All								
Total	**99.41**	**245.66**	**N/A**			**103.66**	**189.31**	**147.87**

13.5.1.2 Important Species Habitat

As described in **Section 13.1.2**, limited species data was available and provided for the Proposed Project. However, information regarding the Cayman Parrot is available for the Proposed Project and the estimated direct impacts are summarized as follows. No other delineated areas of species of concern were identified as part of the data source collection (**Section 13.1.2**). However, potential mitigation measures will be described in **Section 13.6** for species of concern identified by the DoE.

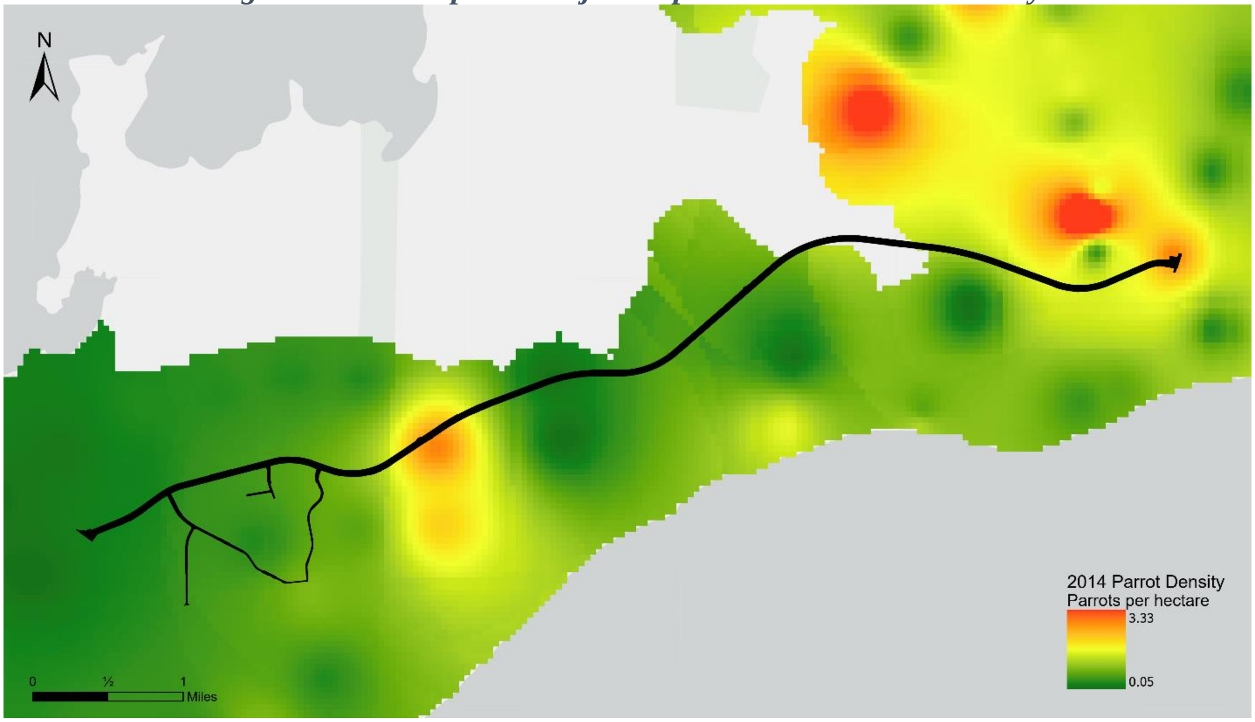
The Proposed Project is estimated to directly impact 80.7 ac (32.7 ha) of Parrot Nesting Habitat (**Figure 13-10)**. This accounts for 2.9% of total Parrot Nesting Habitat within the EIA study area (based on geospatial data provided by DoE in September 2023). Parrot density along the Proposed Project ranges from 0.04 to 0.6 parrots per ac (0.1 to 1.5 parrots per ha), with an average density of 0.2 parrots per ac (0.5 parrots per ha) (**Figure 13-11**).

Figure 13-10: Proposed Project Impact on Parrot Nesting Habitat



Source: Esri, DoE

Figure 13-11: Proposed Project Impact on 2014 Parrot Density



Source: Esri, DoE

13.5.2 Indirect Impacts

Indirect impacts include effects that are reasonably foreseeable/probable, happen at some future time other than direct impacts, are located beyond the location of direct impact, and are caused by the project's direct effects. At this stage indirect impacts were not quantified; however, the following section will discuss indirect impacts that could result from the Proposed Project and considered within the Qualitative Impact Assessment (**Section 13.5.3**).

13.5.2.1 Habitat fragmentation

Habitat fragmentation occurs when a large area of habitat is broken up into small, isolated areas. The resulting smaller habitat areas may be too small for some species to continue to use the area. The action that results in habitat fragmentation could also create a barrier restricting species movement between habitat area, as with roadways. The Proposed Project is a new roadway that will traverse undeveloped land. The main habitat in which the Proposed Project will impact through fragmentation is the CMW. The Proposed Project "hugs" the edge of development on the southern edge of the CMW and thus reduces the magnitude of habitat fragmentation (compared to an alignment further within the CMW). Overall, it is estimated that 571.0 ac (231.1 ha) of habitat could be fragmented, leaving 8,000 ac (3,237 ha) of contiguous CMW (92.4%) remaining.

13.5.2.2 Hydrologic connectivity

Impacts on the hydrology of natural resources include alteration of water flow, water levels and surface drainage, which may be harmful to the CMW, Mastic Reserve and Meagre Bay Pond. Similar to the flooding concerns, the construction of the roadway has the potential to alter the natural flow paths along the roadway alignment. This roadway traverses delicate habitat with important baseline flow patterns, such as the natural flushing of the Meagre Bay Pond into the

CMW and the fresh/salt water hydrologic gradients in the CMW. The roadway has the potential to alter these flow patterns and cause impacts to the natural resources that they serve. See the **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** for additional details.

13.5.2.3 Wildlife/roadway collisions

As previously described, a new road can split a habitat. The animals that use that habitat may be deterred from crossing the road, but some may not. Collisions with wildlife will be inevitable unless measures are taken to reduce the risk. Some of these measures are described in **Section 13.6: Mitigation Measure Considerations**.

13.5.2.4 Noise

Noise generated from roadway construction and operation can cause negative impacts to wildlife, such as behavioural changes, communication difficulties, reduced hunting areas, stress, migration changes, cognitive problems, and physiological stress. Some animals are able to acclimate to changes in the noise environment, while others may not. See the **Chapter 9: Noise and Vibration** for additional details regarding predicted noise levels along the Proposed Project corridor.

13.5.2.5 Light pollution

Lighting from roadways can cast light into habitat that is usually dark at night. This can have several negative effects on the species within the habitat including, but not limited to, disorientation, disruption to the circadian rhythm, and increased road mortality by species, or their prey, being attracted to lighting. At this stage, the lighting for the Proposed Project is conceptual. However, light fixtures and luminaires can be chosen to greatly reduce the impact of night-time lighting on the surrounding habitats and should be considered as the Proposed Project progresses during the detailed design phase, outside of this EIA.

13.5.2.6 Spread of invasive species

Invasive species are species that have been introduced to places outside of their natural range that have negative impacts on the native biodiversity. Invasive flora often thrives in disturbed land and along roads. These species compete, and often outcompete, with native species for resources. Successful invasive flora can take over a site and alter the surrounding ecosystem and food web. Invasive flora found on Grand Cayman include, but is not limited to, Brazilian pepper (*Schinus terebinthifolia*), wild tamarind (*Leucaena leucocephala*), and Australian pine (*Casuarina equisetifolia*). The former two species thrive in disturbed areas and quickly outcompete native flora. Monitoring and maintenance within and adjacent to the Proposed Project may be required to control the spread of invasive species resulting from the Proposed Project.

13.5.3 Qualitative Impact Assessment

A qualitative impact assessment was performed for the Baseline Condition and Proposed Project to identify the significance of the potential effects. The assessment comprised of three steps, including (1) rating the value of features, (2) determining the magnitude of impact, and (3) identifying the overall assessment score. Methodology is described in **Section 13.3.5: Qualitative Assessment** and **Appendix E - Shortlist [Alternatives] Evaluation: Attachment F - Terrestrial Ecology – Assessment of Alternatives**. The results of the qualitative assessment are described in the following subsections.

13.5.3.1 Determination of Value

The value of the identified habitat types was rated for the qualitative impact assessment. Potential ratings included negligible, low, medium, high, and very high.

Cayman Island publications, primarily the 2009 NBAP and 2013 NCA, were reviewed to determine the value ranking for each broad habitat category. The functional values calculated with UMAM for each habitat type are also described in terms of qualitative description of ecological value based on the calculated, quantitative functional values.

Man-Modified Land Uses: Based on the 2009 NBAP, urban and man-modified areas are not currently represented in the protected areas of the Cayman Islands. Urban and man-modified areas are a result of human activity and result in the loss of the previous primary habitat once established in that area. Urban and man-modified areas have already resulted in habitat destruction, habitat fragmentation, spread of invasive species, and/or interruption of wildlife corridors. While not primary habitat, some man-modified land uses, such as man-modified with and without trees and pasture habitats, provide habitat (if limited to marginal foraging and sheltering opportunities) for certain animal species and include native fauna, as noted by field biologists. Examples of native fauna that were documented within these land uses are provided in the habitat descriptions in **Appendix K.2: Terrestrial Habitat Descriptions**.

Due to the low importance and local scale significance, man-modified land uses receive a rating of **"Low"** on the Value scale.

Functional values were calculated for the three man-modified land uses that may provide some habitat benefit: man-modified with trees; man modified with-out trees; and pasture. Five data points were collected for the man-modified with trees land use, of which the functional value ranged from 0.35 to 0.65. The functional value for the man-modified without trees land use ranged from 0.20 to 0.65 for the 10 data points collected. Only one data point was collected for the pasture land use, of which the functional value was calculated at 0.45. The functional values calculated with UMAM indicate that these land uses are of lower ecological value with some data points of moderate value.

Upland habitats: Based on the 2009 NBAP, natural woodland is a rarity in the Cayman Islands and dry forest represents the most biodiverse of the terrestrial habitats in the Cayman Islands.

Due to the high importance and national significance, upland habitats receive a rating of **"High"** on the Value scale.

Functional values for dry forest and woodland ranged between 0.55 to 0.75, out of 1, for the six data points collected. Only one data point was collected for the palm hammock habitat type and this data point had a functional value of 0.70. The functional values of both the dry forest woodland and palm hammock indicate that these habitats are functioning on a moderate level.

Wetland habitats: Based on the 2009 NBAP, mangrove (wetland) habitats constitute one of the Cayman Islands' most undervalued and severely impacted habitats. Mangroves contribute significantly to the biodiversity of both terrestrial and marine ecosystems. The black mangroves within wetland habitats provide nesting habitat for a significant portion of Grand Cayman's national bird, the Cayman Parrot.

Due to the high importance and national significance, wetland habitats receive a rating of **"High"** on the Value scale.

Functional values for the 10 data points collected for Meagre Bay Ponds, pools, and mangrove lagoons habitat type ranged from 0.53 to 0.87. Only one data point was collected for the seasonally flooded / saturated semi-deciduous forest habitat type and this data point had a functional value of 0.57. Thirty-two field data points were collected for the seasonally flooded mangrove forest and woodland habitat type of which the functional values ranged from 0.50 to 0.90. The functional values for these three wetland habitat types indicate that they are functioning on a moderate level.

Parrot habitat (nesting and density): Parrot habitat represents habitat for the National Bird, the Cayman Parrot. Based on the 2009 NBAP, the Cayman Parrot is an endemic, near-threatened species. Current factors affecting the parrot include habitat loss, habitat fragmentation, introduced predators, human impact, and road traffic.

Due to its high importance, national significance, and protection under Part 1 Section 1 of the 2013 NCA, parrot habitat receives a rating of **"High"** on the Value scale.

13.5.3.2 Determination of Magnitude of Impact

The magnitude of the Proposed Project impact was determined for each identified habitat type within the limits of the Proposed Project by estimating the potential extent of the effect of the Proposed Project. Potential ratings included Negative, Negligible, and Positive. Negative and Positive impacts were further categorized as Major, Moderate, and Minor.

Man-Modified land uses: The Proposed Project is estimated to have a direct impact to 90.08 ac (36.45 ha) of man-modified land uses. The majority (75%) of the impacts to man-modified land uses would be to the man-modified with trees and man-modified without trees land use. Each of these having similar amounts of impact, 32.70 ac (13.23 ha) and 34.77 ac (14.07 ha) for man-modified with trees and man-modified without trees, respectively. These land uses are mostly found within or on the outskirts of residential areas located on the west and east ends of the Proposed Project. Though not necessarily of high or medium importance and rarity, these land uses are often adjacent to higher valued habitats and provide a buffer for species between the higher value habitats and nearby development. The Proposed Project will potentially have indirect impacts to these land uses, such as reduced hydrologic connectivity and habitat fragmentation, as discussed in **Section 13.5.2: Indirect Impacts**.

Provided the acres of impact and buffer from high value habitats, the Proposed Project is estimated to have a measurable negative impact on man-modified land uses and adjacent habitats. However, the Proposed Project is not estimated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat or surrounding habitats. Therefore, the Proposed Project receives an **"Intermediate Negative"** score on the Magnitude of Impact scale for man-modified land uses.

<u>*Upland habitats:*</u> The Proposed Project is estimated to have a direct impact to 5.34 ac (2.16 ha) of upland habitats. The majority (68%) of these impacts would be to dry forest and woodland (3.61 ac/1.46 ha). The Proposed Project will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, as discussed in **Section 13.5.2: Indirect Impacts**.

Provided the low acreage of impact, the Proposed Project is estimated to have a measurable, but insignificant negative impact on upland habitats. Therefore, the Proposed Project receives a **"Minor Negative"** score on the Magnitude of Impact scale.

<u>*Wetland habitats:*</u> The Proposed Project estimated to have a direct impact to 150.24 ac (60.80 ha) of wetland habitat. The majority (99%) of the impacts are to seasonally flooded mangrove forest and woodland (148.29 ac/60.01 ha). The Proposed Project will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, as discussed in **Section 13.5.2: Indirect Impacts**.

The Proposed Project is estimated to have a measurable negative impact on wetland habitats based on the acreage of impact. However, the Proposed Project is located along the southern perimeter of the CMW which reduces the degree to which it may fragment this habitat. Additionally, south of the Proposed Project is developed to various degrees. This too lessens the impact of habitat and hydrological fragmentation. Given the location of the Proposed Project and the large-scale size of the CMW, ~ 8,655 ac (3,502 ha), the Proposed Project is not estimated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat. Therefore, the Proposed Project receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

<u>*Parrot Habitat (Nesting and Density):*</u> The Proposed Project is estimated to have a direct impact on 80.7 ac (32.7 ha) of parrot nesting habitat. This accounts for 2.9% of total parrot nesting habitat within the EIA study area (based on geospatial data provided by DoE in September 2023). Parrot density along the Proposed Project ranges from 0.1 to 1.5, with an average density of 0.2 parrots per ac (0.5 parrots per ha) (**Figure 13-11**) (2014 geospatial data provided by DoE). The Proposed Project will potentially have indirect impacts on the parrot and its associated habitat, such as noise and wildlife-vehicular collisions. According to Haakonsson et al. (2017), the growth trend of the Grand Cayman Parrot has been increasing over time despite the effects of anthropogenic and natural disturbances, with an estimated 2014 parrot population size of 6,395 on Grand Cayman.

Provided the acres of impact and density, the Proposed Project is estimated to have a measurable negative impact on parrot habitat. However, provided the estimated parrot population and growth trend, the Proposed Project is not estimated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat or population levels. Therefore, the Proposed Project receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

13.5.3.3 Overall Assessment Score

The overall assessment score was developed by combining the ratings for the value of identified habitats and the estimated magnitude of impact into an Overall Qualitative Rating for the Proposed Project shown in **Table 13-11.**

Table 13-11: Summary Table of Qualitative Impacts on Terrestrial Ecology Resources

Resource	Proposed Project
Man-Modified	Slight Adverse
Upland Habitats	Slight Adverse
Wetland Habitats	Large Adverse
Parrot Habitat *(Cayman Parrot Nesting and Density)*	Large Adverse
Overall Qualitative Rating	**Large Adverse**

The Proposed Project is anticipated to impact a total of 245.66 ac (99.41 ha) of terrestrial habitats and man-modified land uses including 80.7 ac (32.7 ha) of parrot habitat. Most of these estimated impacts are to wetland habitats (150.24 ac [60.8 ha]), man-modified land uses (90.08 ac [36.45 ha]), and parrot nesting habitat (80.7 ac [32.7 ha]). Based on the ratings for these three habitats, "Large Adverse", "Slight Adverse", and "Large Adverse" respectively, the Proposed Project was determined to have an overall qualitative rating of **"Large Adverse"**.

13.5.4 Monetary Valuation

The monetary valuation of ecosystem services is based on the quantified direct impacts in **Section 13.5.1: Direct Impacts** and applicable categories within the 2020 Cayman Islands Ecosystem Accounting. Based on the direct impacts in **Section 13.5.1: Direct Impacts**, only the categories of Carbon Sequestration and Amenity Value are applicable to the Proposed Project and have been incorporated into the Proposed Project Cost Benefit Analysis (CBA).

13.5.4.1 Carbon Sequestration

Ecosystem services from carbon sequestration include the total tonnes of CO_2e sequestered each year (tCO_2e/yr) based on the 2020 Cayman Islands Ecosystem Accounting. **Table 13-12** shows the average sequestration rate by habitat type utilised within the 2020 Cayman Islands Ecosystem Accounting (**Appendix K.5: 2020 Cayman Islands Ecosystem Accounting**).

Table 13-12: Carbon Sequestration Rates by Habitat Type ($tCO_2e/ha/yr$)

Habitat	Murray et al. (2011); IUCN (2017)	Alongi (2014)[1]	Midpoint
Terrestrial			
Mature tropical forest	2.3	-	2.3
Marine			
Seagrass	4.4	2	3.2
Saltmarsh	8	5.5	6.8
Mangroves	6.3	6.4	6.3
Estuaries	-	1.7	1.7
Shelves	-	0.6	0.6

Table notes: [1]The values reported were converted from $gC/m^2/yr$ to $tCO_2e/ha/yr$ using the IPCC (2018) tC to tCO2e conversion factor of 3.67 gram to tonne and m2 to ha conversion factors.

Source: (EFTEC & Joint Nature Conservation Committee, 2022)

Sequestration rates for some habitat categories not offered in 2020 Cayman Islands Ecosystem Accounting (e.g., pasture, man-modified without trees) are not available for the Cayman Islands specifically. The Roads habitat category was assumed to have no carbon sequestration potential. The remainder of habitat categories were assumed to utilise the Grassland, General habitat category from the European Environment Agency's carbon storage data sets (Carbon storage (europa.eu). The Grassland, General total carbon sequestration rate is listed as 0.24 MgCarbon/ha/yr, which equates to 0.26 tCarbon/ha/ya.

Table 13-13 shows the hectares of impact, appropriate habitat sequestration rate, and overall carbon sequestration rate for the Proposed Project. Applicable WebTAG carbon rates will be applied and represented within the Proposed Project CBA.

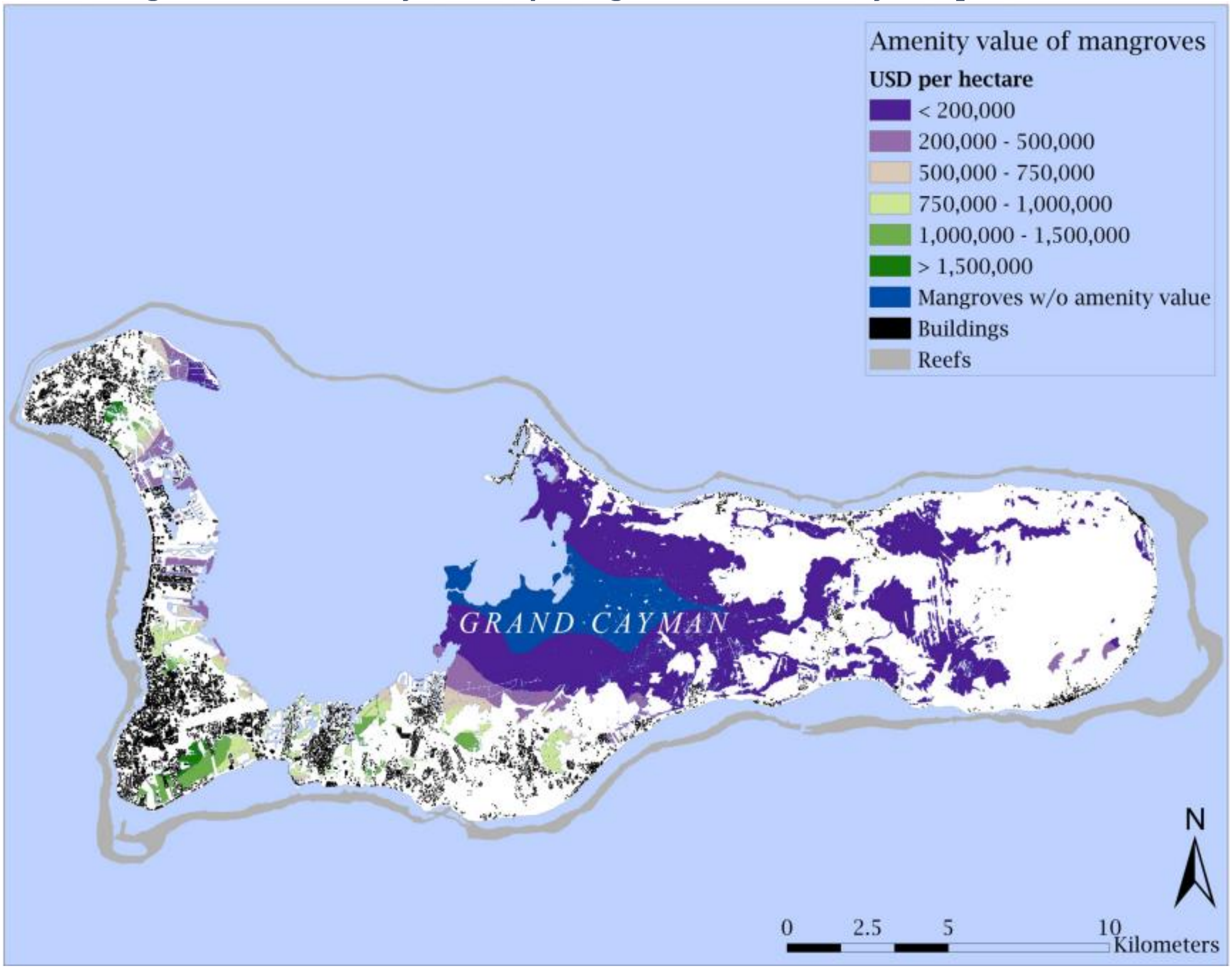
Table 13-13: Carbon Sequestration Rates by Alternative

Habitat	Direct Impact (Hectares)	Sequestration rate ($tCO_2e/ha/yr$)	Impacted Sequestration rate (tCO_2e/yr)
Commercial	0.85	0.26	0.2
Institutional	0.04	0.26	0.0
Man-made Pond	0.13	0.26	0.0
Man-modified with Trees	13.23	2.3	30.4
Man-modified without Trees	14.07	0.26	3.7
Pasture	6.24	0.26	1.6
Residential	0.93	0.26	0.2
Roads	0.96	0	0.0
Dry Forest and Woodland	1.46	2.3	3.4
Invasive Species - *Casuarina*	0.13	2.3	0.3
Palm Hammock	0.57	2.3	1.3
Ponds, Pools, and Mangrove Lagoons	0.14	6.3	0.9
Seasonally Flooded / Saturated Semi-deciduous Forest	0.65	6.3	4.1
Seasonally Flooded Mangrove Forest and Woodland	60.01	6.3	378.1
Total	**99.41**	**-----**	**424.2**

13.5.4.2 Amenity Value

Ecosystem services from amenity value are measured in the number of houses and correlating amenity value to mangroves based on the 2020 Cayman Islands Ecosystem Accounting.

Figure 13-12: Amenity Value of Mangroves on Grand Cayman per Hectare



Source: Guzman et al., 2017
Source data for mangroves is obtained from the DoE habitat map.

The amenity value of mangroves, in USD/ha on Grand Cayman, is depicted in **Figure 13-12**, which was determined by Guzman et al (2017); they spatially applied hedonic pricing to estimate the amenity value of mangroves based on their location in Grand Cayman. The spatial data amenity value data obtained from Guzman et al. was overlaid with the Proposed Project. Where the Proposed Project intersected the amenity values shown on the map, the intersected area was calculated and the value per ha was determined. **Table 13-14** provides the estimated hectares of impact within each range of amenity values and the total estimated amenity value for the Proposed Project. Amenity value is not calculated on a yearly basis but is considered a one-time cost at the time of construction.

Table 13-14: Amenity Value of Impacted Mangrove Habitats (based on Figure 13-12)

Project Impact (ha)	Mangrove area valuation (USD*/ha) (Average value from Figure 13-12)	Amenity Value Loss (CI$)	Amenity Value Loss (USD*)
44.7	100,000	$3,754,800	$4,470,000
6.7	350,000	$1,969,800	$2,345,000
1.3	625,000	$682,500	$812,500
2.1	825,000	$1,455,300	$1,732,500
0.4	1,250,000	$420,000	$500,000
0	1,500,000	$0	$0
Total Amenity Value Loss		**$8,282,400**	**$9,860,000**

**2017 USD*
***US Dollars have been converted from CI Dollars at a rate of $0.84 CI = $1.00 US; $1.00 CI = $1.19 US.*

13.5.5 Potential Construction and Operation Impacts

Potential impacts during the construction and operation phases of the project were further assessed by various attributes/variables to determine the magnitude of impact, importance/sensitivity of the resource, and impact significance. These criteria were determined within **Section 13.3.5: Qualitative Assessment**. Construction phase impacts are included in **Table 13-15** and operation phase impacts are included in **Table 13-16**.

13.5.5.1 Construction Phase

The Proposed Project is anticipated to be built in multiple phases. The initial phase, anticipated for 2026, would include two vehicular travel lanes**, one** in each direction, for both Section 2 and Section 3**.** Additional features anticipated by 2036 include dedicated bus lanes in Section 2 and 3 and a sidewalk, a micromobility path, utilities, and a solar panel canopy in all of Section 2 and select parts of Section 3. By 2046, additional vehicular travel lanes are anticipated to be incorporated in Section 2 while Section 3 will see the rest of the sidewalk, micromobility path, and solar panel canopy completed. No further features are anticipated for 2060 in Section 2 while Section 3 will see additional vehicular travel lanes incorporated as was the case with Section 2 in 2046. 2060 would be considered the final build out of the facility. Building the Proposed Project in phases, with only a limited portion of the corridor under construction at one time, will minimise environmental impacts to the greatest extent practicable. For additional information on the corridor sections and proposed timeline, refer to **Section 6.1: Corridor Features and Timeline** for additional details.

In addition, construction best practices will be adhered to during construction (e.g., strict adherence to erosion and sediment control measures, post-construction regrading/revegetation/ enhancement, construction monitoring, spacing of new culverts, wildlife crossings, etc.). Throughout the duration of construction and in the areas of the Proposed Project, construction activities should be performed in a manner that minimises construction or waste materials from entering sensitive areas (e.g., wetlands, special species habitats, etc.). Prior to the beginning of any area-specific construction activities, the non-impacted wetlands and designated upland buffers that are within the project limits, and that are within 50 ft (15.2 m) of any project activities, should be clearly flagged or demarcated for the duration of the construction activity within that area. It is recommended that the NRA notify the contractors and subcontractors that no activities are to occur in these marked areas. It is also recommended that flagging of non-impacted sensitive areas and installation of erosion and sediment (E&S) controls be implemented for a given portion of the Proposed Project prior to construction in that area. Likewise, final stabilization should be achieved in a given area prior to removal of the E&S controls in that area. It is recommended that E&S controls be inspected and maintained in order to minimise impacts to surface waters and wetlands. More detailed construction means and methods are included in **Chapter 6: Proposed Project – Engineering Features**.

Potential construction phase impacts were assessed, including the following:

- Earthwork and land clearing resulting in habitat loss
- Introduction or spread of invasive species
- Loss of ecosystem services
- Visual and noise intrusion

These potential impacts are adverse and are typically long-term, except for construction noise, which is temporary. Potential impacts are high in sensitivity. Potential construction phase impacts are summarized in **Table 13-15**.

Table 13-15: Summary of Construction Phase Impacts on Terrestrial Ecology Resources

Receptor / Resource / Impact Summary	**Description / Potential Effect (*include likelihood and certainty)***	**Type / Temporal / Geographic**	**Magnitude**	**Sensitivity**	**Significance**
Terrestrial habitat functional loss	Clearing of land and earthwork required for construction is estimated to result in habitat functional loss. Based on **Section 13.4.3,** the terrestrial habitats being impacted are generally of high value (sensitivity), have an intermediate negative magnitude of change, and result in an overall Large Adverse Impact. This effect has a high likelihood of occurrence and has been identified with high certainty.	Adverse, Long-Term, Local	Intermediate Negative	High	Large Adverse

Receptor / Resource / Impact Summary	Description / Potential Effect (*include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude	Sensitivity	Significance
Important species habitat loss	Clearing of land and earthwork required for construction is estimated to result in loss of important species habitat. Based on **Section 13.4.3**, the important species habitat being impacted is generally of high value (sensitivity), have an intermediate negative magnitude of change, and result in an overall Large Adverse Impact. This effect has a high likelihood of occurrence and has been identified with high certainty.	Adverse, Long-Term, Local	Intermediate Negative	High	Large Adverse
Spread of invasive species	Introduction or spread of invasive species within adjacent habitats due to the intrusion of construction vehicles, equipment, and materials is a potential effect of the construction phase. This effect has a medium likelihood of occurrence and has been identified with low certainty.	Adverse, Long-Term, Local	Intermediate Negative	High	Large Adverse
Loss of ecosystem services from habitat removal	Clearing of land and earthwork required for construction is estimated to result in habitat removal, and the associated monetary loss of the ecosystem services provided by those habitats. The monetary valuation of ecosystem services is based on the quantified direct habitat impacts and the Cayman Islands Ecosystem Accounting document. This effect has a high likelihood of occurrence and has been identified with high certainty.	Adverse, Long-Term, Regional	Intermediate Negative	High	Large Adverse

Receptor / Resource / Impact Summary	Description / Potential Effect (*include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude	Sensitivity	Significance
Visual and Noise intrusion	Construction activities typically result in the temporary increase in noise level due to construction equipment, delivery vehicles, and commuting crew members. Construction activities may also result in temporary visual effects, including vegetation removal and construction equipment, such as cranes. This effect has a high likelihood of occurrence and has been identified with high certainty.	Adverse, Temporary, Local	Minor Negative	High	Slight Adverse

13.5.5.2 Operation Phase

Potential operation phase impacts were assessed and may include the following:

- Habitat fragmentation
- Wildlife roadway collisions
- Impacts to hydrologic connectivity
- Visual and noise intrusion from lighting and maintenance work

These potential impacts are adverse and long-term and are typically regional, except for visual and noise intrusion, which is local. Potential impacts are high in sensitivity. Potential operation phase impacts are summarized in **Table 13-16**.

Table 13-16: Summary of Operational Phase Impacts on Terrestrial Ecology Resources

Receptor / Resource / Impact Summary	Description / Potential Effect (*include likelihood and certainty)*	Type / Temporal / Geographic	Magnitude	Sensitivity	Significance
Terrestrial habitat fragmentation	The Proposed Project is a new roadway that will traverse undeveloped land. Although avoided to the greatest extent practicable, the roadway will result in habitat fragmentation and could create a barrier restricting species movement between habitat area following construction. This effect has a high likelihood of occurrence and has been identified with low certainty.	Adverse, Long-Term, Regional	Minor Adverse	High	Slight Adverse
Important species interactions	Potential for conflicts with important species through potential for roadway collisions. This effect has an unknown likelihood of occurrence and has been identified with an unknown certainty due to limited data availability.	Adverse, Long-Term, Regional	**	High	**

Receptor / Resource / Impact Summary	**Description / Potential Effect (*include likelihood and certainty)***	**Type / Temporal / Geographic**	**Magnitude**	**Sensitivity**	**Significance**
Impact to hydrologic connectivity of adjacent habitats	Construction of the Proposed Project has the potential to alter the existing hydrologic connectivity of habitats within the EIA Study Area. Routine maintenance is recommended so that hydrologic connectivity isn't blocked by debris build-up or failing culverts. This effect has a medium likelihood of occurrence and has been identified with medium certainty.	Adverse, Long-Term, Regional	Minor Adverse	High	Slight Adverse
Visual and Noise intrusion	The operation of the Proposed Project will increase noise levels along the corridor due to the introduction of traffic. Although no specific noise thresholds are established for non-human occupied areas, the increased noise levels have a potential to adversely impact species adjacent to the corridor. The Proposed Project may also result in visual effects to adjacent habitats from the introduction of traffic and pedestrian facilities. This effect has a high likelihood of occurrence and has been identified with medium certainty.	Adverse, Long-Term, Local	Minor Adverse	High	Slight Adverse

***Due to the lack of available species migration data as part of the EIA, further evaluation of potential roadway conflicts recommended*

13.6 Mitigation Measure Considerations

The following mitigation hierarchy, in order of best practice first, is outlined in the Cayman Islands EIA Directive (NCC, 2016):

1. *Avoidance - this would require the project to be designed or the site selected to avoid any environmental impacts.*
2. *Reduction/Minimisation - this can be achieved by the addition of mitigation measure considerations such as bundling, screening, or applying abatement technology;*
3. *Compensation - where impacts have been unavoidable this method can be used and can involve the improvement of a related environmental issue for example replanting of a deforested area in an alternative location.*
4. *Remediation/Restoration - this option would involve the clean-up and restoration of an area where the environmental impact is unavoidable; and*
5. *Enhancement - this method involves the improvement of the site beyond the existing baseline.*

Throughout the ES, the term minimisation is used synonymously with the term reduction; and the term restoration is used synonymously with the term remediation.

The mitigation hierarchy was followed to the greatest extent practicable during the assessment of alternatives and during development of the conceptual, planning-level design. Further mitigation best practices will be considered during detailed design, outside of the EWA EIA.

The assessment of alternatives process evaluated alternative corridors for meeting the CSFs, engineering constraints, social environmental constraints, and natural environment constraints. Through the assessment of alternatives process, the Proposed Project corridor has been shifted from the original 2005 Gazetted corridor (**Figure 13-13**) to avoid impacts to the natural environment, including to NT Property (**Figure 13-14**) and the Mastic Reserve and Mastic Trail (**Figure 13-15**). A full suite of maps demonstrating the avoidance and minimisation achieved with the Proposed Project compared to the original 2005 Gazetted corridor can be viewed in **Appendix K.6: Proposed Project and Gazetted Corridor Mapping**.

Figure 13-13: Gazetted Corridor and Proposed Project

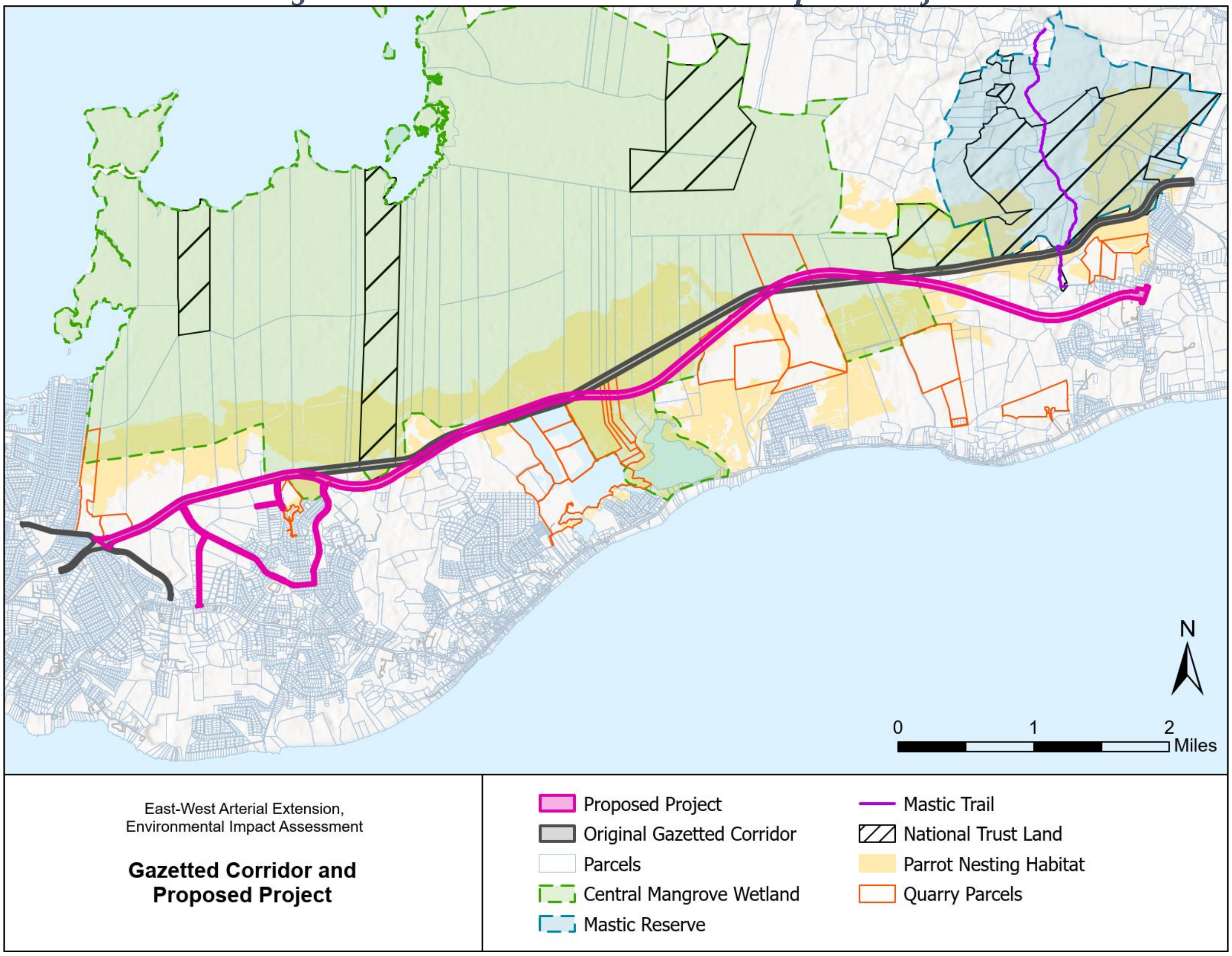


Figure 13-14: Gazetted Corridor and Proposed Project, Map 2 of 5

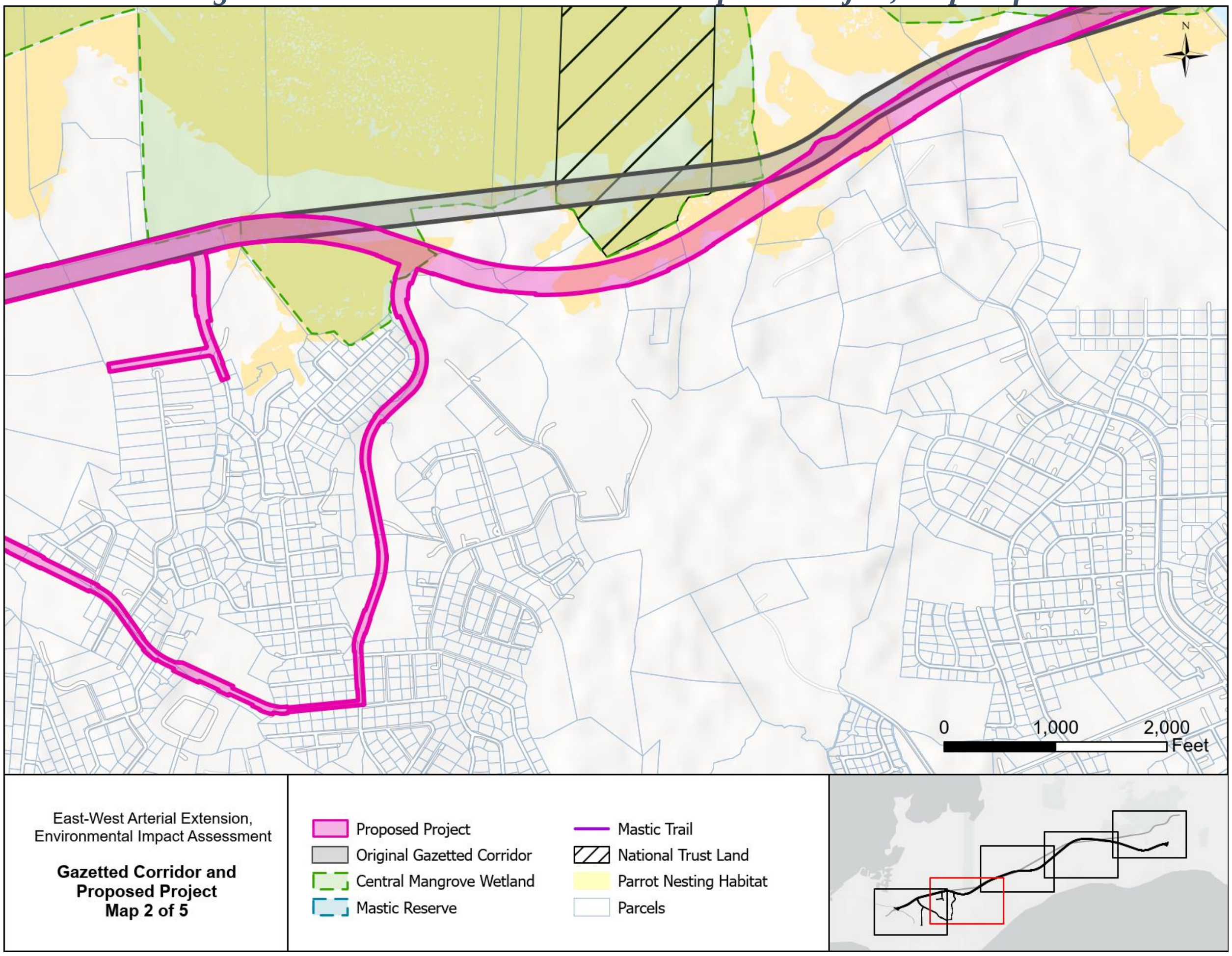
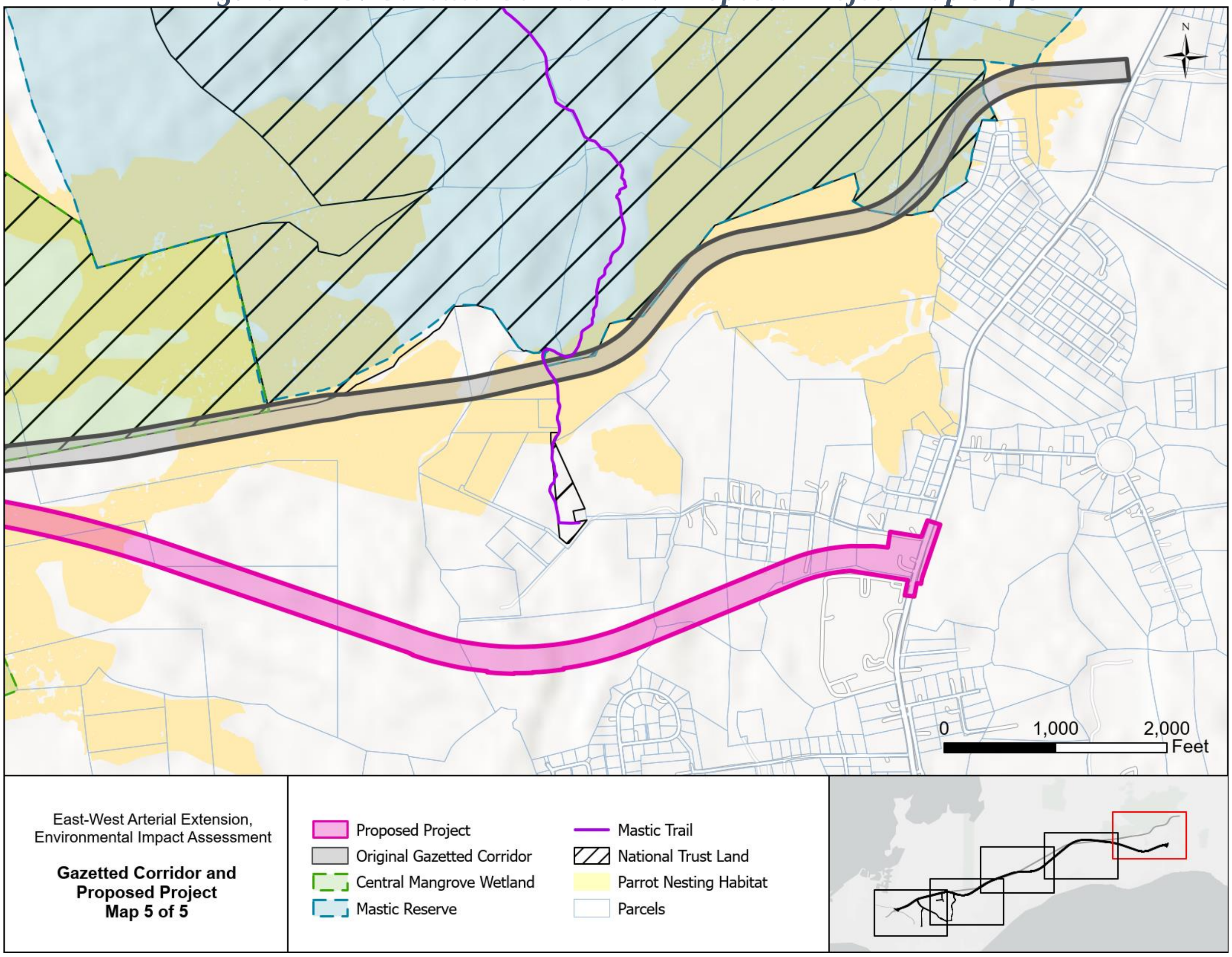


Figure 13-15: Gazetted Corridor and Proposed Project Map 5 of 5



13.6.1 Mitigating Terrestrial Habitat Functional Loss

As described**,** enhancement or remediation of habitats could provide functional "lift" to offset functions lost as a result of the Proposed Project. Examples could include replanting/restoring degraded habitat (e.g., active pastureland) or invasive species removal. Habitats identified for enhancement or restoration would be assigned pre-construction and post-construction functional scores. The delta (change) between the two functional scores would then be multiplied by the acreage of the remediated/enhanced habitat to yield functional units gained. As indicated in **Table 13-10**, the total average functional loss for the Proposed Project is 147.87functional units (ranging from 103.66 to 189.31 functional units). An impact factor of 1.0 was assumed, meaning that the post-construction function of any impacted habitat would be 0. As reported in **Table 13-10**, the average score of the poorest habitat, *Invasive Species – Casuarina*, was 0.38 functional score, while the average score of the most valuable habitats, *Seasonally Flooded Mangrove Forest and Woodland* and *Palm Hammock*, was 0.7 functional score. The highest UMAM score of 1.0 does not typically occur in nature, so scores between 0.6 and 0.7 functional score are considered to be a reasonable approximation of scores that could be achieved in situ.

As an example, if two acres of *Invasive Species – Casuarina* habitat with a score of 0.38 functional score were remediated/enhanced to a higher function such as *Palm Hammock* (0.7 functional score) or *Dry Forest and Woodland* (0.63 functional score), the ecological "lift" would be between 0.32 and 0.25. Multiplied by two acres, a total of 0.64 to 0.50 functional units would have been created to offset functional loss.

To offset a functional loss of 147.87 units, assuming an ecological "lift" of 0.25-0.32, the Proposed Project would need to identify approximately 463 to 592 ac (187 to 240 ha) for remediation/enhancement. Accounting for the range of functional loss (103.66 to 189.31 functional units), the Proposed Project could require between 324 ac (103.66 functional units lost/0.32 functional lift) and 757 ac (189.31 functional units/0.25 functional lift) (131 to 306 ha) for remediation/enhancement to offset the functional loss and achieve No Net Loss of Biodiversity.

Table 13-17 provides a summary of the potential mitigation measures that could provide some function "lift" to offset functions lost as a result of the Proposed Project. Further information regarding implementation, responsibilities for implementation, any monitoring and reporting, and actions for non-compliance will be included as part of the separate EMP. The EMP will be reviewed and approved by the EAB prior to the EAB Letter of Final Recommendation.

13.6.2 Potential Construction and Operation Mitigation Measures

The following sections discuss more in depth the measures that can be considered to mitigate the impacts described in earlier sections to the resources of concern. **Table 13-17** details the characterisations used to evaluate the impacts after mitigation considerations have been applied.

Table 13-17: Impact Analysis Factors

Characterisation	Description	Quantitative Measure or Definition of Qualitative Categories
Magnitude	The size or degree of the effects compared against Baseline Conditions or reference levels, and other applicable measurement parameters (e.g., standards, guidelines, objectives)	**Negligible (N) |** Differing from the average Baseline Conditions to a very small degree, but within the range of the natural variation **Very Low (VL) |** Differing from the average Baseline Conditions to a small degree, but very minimally out of the range of the natural variation **Low (L) |** Differing from the average baseline and outside the range of natural variation but less than or equal to appropriate guideline or threshold value **Medium (M) |** Differing from the average baseline and outside the range of natural variation and marginally exceeding a guideline or threshold value **High (H) |** Differing from the average baseline and outside the range of natural variation and exceeding a guideline or threshold value
Geographic Extent	The geographic area over which the effects are likely to be measurable	**Limits of Disturbance (LOD) |** Occurs within the Proposed Project LOD **Outside Limits of Disturbance (OLOD) |** Occurs outside of the Proposed Project LOD, but within the identified Study Area
Timing	Considers when the environmental effect is expected to occur. Timing considerations are noted in the evaluation of the environmental effect, where applicable or relevant.	**Not Applicable (NA) |** Seasonal variations are not likely to change the effect **Applicable (A) |** Seasonal aspects may affect the outcome of the effect
Duration	The time period over which the effects are likely to last	**Short-Term (ST) |** The effect is reversible at the end of construction works **Medium-Term (MT) |** The effect is reversible within a defined length of time **Long-Term (LT) |** The effect is reversible over an extended length of time
Frequency	The rate of recurrence of the effects (or conditions causing the effect)	**Once (O) |** Effects occur once **Occasional (Oc) |** Effects that could occur randomly throughout the project lifetime **Regular (R) |** Effects can occur at regular intervals through construction and/or operation **Continuous (C) |** Effects are continuous throughout construction and operation
Reversibility	The degree to which the effects can or will be reversed (Typically measured by the time it will take to restore the environmental attribute or feature)	**Reversible (R) |** The Baseline Conditions will recover to their standard after the construction works are completed **Partially Reversible (PR) |** Mitigation can return the Baseline Conditions **Not Reversible (NR) |** Mitigation cannot guarantee a return to baseline conditions

13.6.2.1 Design and Construction Phase

During construction, measures can be taken to prevent and/or reduce impacts on and off-site. The following subsection discusses the potential mitigation measure considerations to address the impacts listed in previous sections. **Table 13-18** further details and evaluates the impacts and mitigation measures.

As detailed design advances, the best practices outlined in the mitigation hierarchy will continue to be considered. Avoidance of terrestrial ecology resources will be mostly accomplished through horizontal alignment shifts.

Reduction/minimisation will be accomplished through design refinements that minimise the overall footprint of the Proposed Project. This includes not only reduction/minimisation of direct impacts, but also indirect impacts, such as habitat fragmentation. A key decision was made to delay impacts to the northern part of the corridor for as long as possible. This approach aims to preserve the natural state of the environment and postpone any incidental development that could occur as a result of the corridor's construction. Examples of reduction/minimisation could include:

- Vertical Alignment: Vertical alignment shifts to reduce the impact of roadway fill slopes and in turn minimise impacts to terrestrial ecology resources.
- Typical Section: A modification to the typical section to reduce impacts based on reducing the section width and increasing side slope steepness.
- Intersections/Roundabout Design: A modification to the configuration and locations of interchanges and roundabouts to minimise impacts.

Compensation, remediation/restoration, and enhancement will include design as well as construction best practices. Design considerations will include identification of parcels adjacent to the proposed roadway that could be enhanced or remediated to provide ecological function beyond the current conditions. Examples could include replanting/restoring degraded habitat (e.g., active pastureland), invasive species removal, and placing conservation easements on high value habitats. During construction, best practices could include implementation of erosion and sediment controls, minimising transport of invasive species on construction equipment, and conducting certain activities outside critical times of year for important species (e.g., breeding season for Cayman parrot, migratory season for land crabs, etc.). Long-term impacts and mitigation are described within the Operation Phase (**Section 13.4.2: Baseline Conditions Proposed Project**). Implementation of best practices is described in more detail as follows.

Avoidance of high-quality habitats during detailed design and construction is the first level of mitigation. Habitat mapping and function data established as part of the EWA Extension EIA will be provided to the NRA and detailed design team so that further refinements can be made to avoid high-quality habitats to the extent possible during detailed design. Clear demarcation of work limits at the initiation of construction can avoid and minimise unnecessary vegetation clearing.

Minimisation measures to avoid the extent of impacts, including invasive species control and hydrologic connectivity/quality, should be incorporated during construction. The spread of invasive species within the project area can be minimised by properly disposing of invasive species removed from the site and requiring construction equipment to be cleaned off-site.

Areas of impact during construction will be evaluated for restoration and enhancement. This could include the grading and replanting of impacted areas to reach their previous state, or an enhanced state. Habitat mapping and function data established as part of the EWA Extension EIA will be provided to the NRA and detailed design team in order to guide the appropriate species for replanting.

Table 13-18: Mitigation for Terrestrial Ecology during the Design and Construction Phase Summary

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measure considerations</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Terrestrial habitat functional loss</td><td rowspan="2">Clearing of land and earthwork required for construction is estimated to result in habitat functional loss. This effect has a high likelihood of occurrence and has been identified with high certainty.</td><td rowspan="2">Avoidance of high-quality habitats during detailed design and construction (Clearly demarcate work limits at initiation of construction and minimise unnecessary vegetation clearing).

Delay impacts to the northern part of the corridor for as long as possible.

Replanting/grading of areas of temporary impact within the corridor. Final habitat mapping within the corridor to be provided to the NRA for reference to guide replanting of temporary impact areas.

Potential to enhance or restore non-impacted areas within the project corridor. This could include land contouring, vegetative planting, or invasive species removal.

Functional “lift”, as described in Section 13.6.1, would be the primary form of mitigation proposed for unavoidable terrestrial habitat impacts.</td><td>L</td><td>LOD</td><td>NA</td><td>MT</td><td>R</td><td>PR</td><td rowspan="2">Terrestrial habitat loss</td><td rowspan="2">Not Significant – mitigation measures would limit terrestrial habitat functional loss and provide functional “lift” for unavoidable terrestrial habitat impacts

Note: If mitigation measures are not implemented then functional loss would remain, and No Net Loss of Biodiversity would not be achieved. This would result in a Significant Residual Effect.</td></tr>
<tr><td colspan="6">Assuming incorporation of mitigation measures, the magnitude of impacts would be Low.

Impacts are estimated to occur within the LOD.

The timing is N/A.

The frequency would be Regular, based on construction sequencing.

Portions of the impacted habitat areas may be suitable for replanting/grading. Re-established habitats are estimated to require a Medium-Term duration.

The mitigation measure considerations can be implemented to return a portion of the impacted areas to the Baseline Conditions; therefore, it is considered partially reversible.</td></tr>
</table>

Resource	Potential Effect	Mitigation Measure considerations	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Important species habitat loss	**See Terrestrial habitat functional loss section. Important species are included as part of the calculated terrestrial habitat functional loss.**									
Terrestrial habitat fragmentation	The Proposed Project is a new roadway that will traverse undeveloped land. Although avoided to the greatest extent practicable, the roadway could result in habitat fragmentation and create a barrier restricting species movement between habitat area following construction.	Terrestrial habitat fragmentation can be minimised by shifting the corridor to avoid large tracts of contiguous habitat. Additional mitigation measures, including important species interactions and hydrologic connectivity of adjacent habitats are discussed in the operation phase section (**Section 9.6.2.2**).	L	LOD/ OLOD	NA	LT	C	NR	Fragmentation of larger contiguous ecosystems (such as the CMW)	Not significant - the proposed mitigation measures will limit terrestrial habitat fragmentation
			Assuming incorporation of mitigation measures, the magnitude of impacts would be Low. Impacts are estimated to occur both within and outside of the LOD. The timing is N/A. The duration would be Long-Term, and the frequency would be Continuous, based on construction sequencing. The mitigation measure cannot guarantee a return to the baseline conditions and therefore considered Not Reversible.							

Resource	Potential Effect	Mitigation Measure considerations	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Spread of invasive species	Introduction or spread of invasive species within the study area	The spread of invasive species within the project area can be minimised by properly disposing of invasive species removed from the site and requiring construction equipment to be cleaned off-site. Additional mitigation measures include replanting/restoring cleared areas with native species. The complete exclusion of invasive species cannot be guaranteed due to the presence of invasive species within the EIA Study Area and greater Grand Cayman.	L	LOD	NA	MT	R	PR	Potential spread of invasive species within the study area	Not significant - the proposed mitigation measures will limit the spread of invasive species
			With proper removal of encountered invasive species and cleaning of construction equipment off-site, the estimated chance and magnitude of invasive species spread is considered Low. The control of invasive species is LOD specific and not estimated to be seasonally influenced. Varying phases of construction are estimated throughout the Proposed Project lifecycle; therefore, mitigation measures would be considered a Medium-Term duration and occurring at Regular intervals. It is estimated that the site can return to Baseline Conditions with implementation of the mitigation measure considerations, and therefore considered Partially Reversible.								

Resource	Potential Effect	Mitigation Measure considerations	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Visual and noise intrusion	Construction activities typically result in the temporary increase in noise level due to construction equipment, delivery vehicles, and commuting crew members. Construction activities may also result in temporary visual effects, including vegetation removal and construction equipment, such as cranes. This effect has a high likelihood of occurrence and has been identified with high certainty.	Potential mitigation measure considerations for noise during construction can be found in **Chapter 9: Noise and Vibration.** At this stage, the lighting for the Proposed Project is conceptual. However, light fixtures and luminaires can be chosen to greatly reduce the impact of night-time lighting on the surrounding habitats and should be considered as the Proposed Project progresses. See **Chapter 6: Proposed Project – Engineering Features** for additional details. Supplemental vegetative plantings could provide a visual screen to minimise visual impacts.	L	LOD	A	MT	R	R	Potential noise and visual intrusion into adjacent habitats	Not significant - the proposed mitigation measures will limit visual and noise intrusion
			Assuming incorporation of mitigation measures, the magnitude of impacts would be Low. Impacts are estimated to occur within the LOD. Time of year could impact the sensitivity of certain species to visual and noise stressors; therefore, it is Applicable. Varying phases of construction are estimated throughout the Proposed Project lifecycle; therefore, mitigation measures would be considered a Medium-Term duration and occurring at Regular intervals. The Baseline Conditions will recover to their standard after the construction works are completed, therefore it is considered Reversible.							

13.6.2.2 Operation Phase

During roadway operation (post-construction), measures can be implemented to prevent and reduce impacts on and off-site. The following section discusses potential mitigation measure considerations that could be used to address the impacts listed in previous sections. **Table 13-19** further details and evaluates the impacts and mitigation measure considerations.

These mitigation measures could be implemented during maintenance work of the proposed roadway following construction and may include the following:

- Installation of wildlife demarcation and fencing to increase awareness and create main crossing points for wildlife.
- Collection of species mortality information during operations to identify crossing locations.
- After the construction of hydrologic connectively features, regular and informed maintenance is required for long-term functionality.
- Light fixtures and luminaires can be chosen to greatly reduce the impact of night-time lighting on the surrounding habitats and should be considered as the Proposed Project progresses.
- Vegetative screens (the planting of trees, shrubs, grasses, or other vegetation to serve as a visual screen to obstruction the view of the Proposed Project) can also be planted to minimise visual impacts.
- See **Chapter 9: Noise and Vibration** for details regarding noise levels and potential mitigation measure considerations.

Table 13-19: Mitigation for Terrestrial Ecology during the Operation Phase Summary

<table>
<tr><th>Resource</th><th>Potential Effect</th><th>Mitigation Measure considerations</th><th>Magnitude</th><th>Geographic Extent</th><th>Temporal Extent</th><th>Duration</th><th>Frequency</th><th>Reversibility</th><th>Residual Effect</th><th>Significance of Residual Effect</th></tr>
<tr><td rowspan="2">Important species interactions</td><td rowspan="2">Potential for conflicts with important species through potential for roadway collisions.</td><td rowspan="2">Installation of wildlife demarcation and fencing to increase awareness and create main crossing points for wildlife.

Collection of species mortality information during operations to identify crossing locations.</td><td>**</td><td>LOD</td><td>A</td><td>LT</td><td>C</td><td>PR</td><td rowspan="2">** Due to the lack of available species migration data as part of the EIA, further evaluation of potential roadway conflicts recommended</td><td rowspan="2">** Due to the lack of available species migration data as part of the EIA, further evaluation of potential roadway conflicts recommended</td></tr>
<tr><td colspan="6">Due to the lack of available species migration data as part of the EIA, the magnitude of potential impact is unknown.

Impacts are estimated to occur within the LOD.

Time of year could impact the sensitivity of certain species; therefore, it is Applicable.

The potential mitigation measures and impacts would be Long-Term and Continuous.

Mitigation could return the Baseline Conditions; therefore, it is considered Partially Reversible.</td></tr>
</table>

Resource	Potential Effect	Mitigation Measure considerations	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Impact to hydrologic connectivity of adjacent habitats	Construction of the EWA Extension has the potential to alter the existing hydrologic connectivity of habitats within the EIA Study Area. Potential mitigation consideration for hydrologic connectivity is included in **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** and residual effect estimated to be Not Significant.	The design and inclusion of hydrological features is discussion in **Chapter 6: Proposed Project – Engineering Features** and **Chapter 12: Hydrology and Drainage, Including Climate Resiliency.** After the construction of hydrologic connectively features, regular and informed maintenance is required for long-term functionality.	L	LOD	A	LT	C	PR	Potential for diminished hydrologic connectivity of adjacent habitats	Not significant - the proposed mitigation measures will limit impact to hydrologic connectivity of adjacent habitats
			Assuming incorporation of mitigation measures, the magnitude of impacts would be Low. Impacts are estimated to occur within the LOD. Timing is Applicable. The rainfall that drives hydrology for natural resources experiences seasonal variation. The potential mitigation measures and impacts would be Long-Term and Continuous. Mitigation could return the Baseline Conditions; therefore, it is considered Partially Reversible.							

Resource	Potential Effect	Mitigation Measure considerations	Magnitude	Geographic Extent	Temporal Extent	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Visual and Noise intrusion	The operation of the EWA Extension is estimated to increase noise levels along the corridor due to the introduction of traffic. Although no specific noise thresholds are established for non-human occupied areas, the increased noise levels have a potential to adversely impact species adjacent to the corridor. The Proposed Project may also result in visual effects to adjacent habitats from the introduction of traffic and pedestrian facilities.	See **Chapter 9: Noise and Vibration** for details regarding noise levels and potential mitigation measure considerations. Light fixtures and luminaires can be chosen to greatly reduce the impact of night-time lighting on the surrounding habitats and should be considered as the Proposed Project progresses. Vegetative screens can also be planted to minimise visual impacts.	L	LOD	A	LT	C	PR	Potential increased noise and visual intrusion	Not Significant – the proposed mitigation measures will limit impacts from visual and noise intrusion
			Assuming incorporation of mitigation measures, the magnitude of impacts would be Low. Impacts are estimated to occur within the LOD. Time of year could impact the sensitivity of certain species; therefore, it is Applicable. The potential mitigation measures and impacts would be Long-Term and Continuous. Mitigation could return the Baseline Conditions; therefore, it is considered Partially Reversible.								

13.6.3 Summary of Terrestrial Ecology Potential Mitigation Measures

The Proposed Project is estimated to result in an average loss of 147.87 functional units. As described**,** enhancement or remediation of habitats could provide functional "lift" to offset functions lost as a result of the Proposed Project.

Accounting for the range of functional loss (103.66 to 189.31 functional units), the Proposed Project could require between 324 ac (103.66 functional units lost/0.32 functional lift) and 757 ac (189.31 functional units/0.25 functional lift) (131 to 306 ha) for remediation/enhancement to achieve No Net Loss of Biodiversity. The range in the potential mitigation needed is due to variability in UMAM scores both among and within different habitat types being impacted and enhanced/remediated. The UMAM data used for this planning-level analysis provides a preliminary estimate of mitigation needs. As design advances outside of the EIA, additional data will be collected for the specific habitat types being impacted. Likewise, specific properties for enhancement/remediation will be identified and additional data will be collected to further refine the mitigation required. This will occur after each phase is designed and before each phase is constructed. A line item is being carried in the project construction cost estimate (**Chapter 6: Proposed Project - Engineering Features** and **Appendix F.7.1, Appendix F.7.2, and Appendix F.7.3 – Construction Cost Estimates**) for "Potential Terrestrial Ecology Mitigation Consideration" that includes the estimated cost of land acquisition and enhancement/restoration activities.

As outlined above, implementation of the functional "lift" mitigation measures would create functional units equal to the functional units lost, therefore achieving No Net Loss of Biodiversity.

The following is a summary of the additional mitigation measures that would provide functional "lift" to offset the lost functions within the limits of the Proposed Project corridor. These measures were chosen based on industry standards with consideration of project specifics.

During the design and construction phase, mitigation measures would include:

- Enhancement and restoration of non-impacted areas within the project corridor through invasive species removal and native vegetative planting.
- Minimisation of habitat fragmentation by minimising the footprint and shifting the corridor to avoid contiguous tracts of habitat.
- Minimisation of invasive species spread by properly disposing of invasive species and requiring construction equipment to be cleaned off-site.

In the operation phase mitigation measures would include:

- Installation of wildlife demarcation and fencing to increase awareness and create main crossing points for wildlife.
- Maintenance of hydrologic connectivity features regularly.
- Installation of light fixtures to reduce night-time lighting on surrounding habitats.
- Supplemental vegetative plantings to provide visual screens.

Additional information regarding implementation, responsibilities for implementation, any monitoring and reporting, and actions for non-compliance will be included as part of the separate EMP. Due to the phased development of the project, a review of the mitigation measures and design solutions will be continually evaluated during the design, construction, and operation phases to allow for successful mitigation. If the mitigation measure considerations are not implemented, the Large Adverse impact to terrestrial ecology resources (**Section 13.5.3.3: Overall Assessment Score**) would remain.

14 Cultural and Natural Heritage

The purpose of this chapter is to identify and assess potential impacts of the EWA extension to cultural and natural heritage sites within the EIA study area. In the 2022 *Guidance and Toolkit for Impact Assessments in a World Heritage Context*, the United Nations Educational, Scientific and Cultural Organization (UNESCO) defines heritage as:

> *"All inherited assets which people value for reasons beyond mere utility. Heritage is a broad concept and includes shared legacies from the natural environment, the creations of humans and the creations and interactions between humans and nature. It encompasses built, terrestrial, freshwater and marine environments, landscapes and seascapes, biodiversity, geodiversity, collections, cultural practices, knowledge, living experiences, etc."*

Grand Cayman is rich in heritage resources, including natural resources (e.g., the CMW) and cultural resources (e.g., Heritage Register sites). Many ecosystems and habitats carry national cultural significance for residents of the Cayman Islands. These features include resources that are protected by legislation and sites that are of interest at the local and/or national level. Resources with heritage value also often have socio-economic, ecosystem service, hydrological, or resiliency values, among others. While this chapter of the ES discusses the heritage aspect of resources only, the disciplines of study described in this ES are interlinked and influenced by each other. Impacts or mitigation described for one area of study (e.g., habitat fragmentation described in **Chapter 13: Terrestrial Ecology**) may also be applicable to this chapter, and vice versa. Overlap between disciplines and resources is addressed in **Section 14.1.3: Description and Assessment of Impacts**.

This chapter evaluates the potential effects of the Proposed Project on identified cultural resources, which are described in **Section 14.2: Baseline Conditions**. The Future No-Build is assumed to include no additional cultural and natural heritage impacts. Therefore, within this chapter the Baseline Conditions (synonymous with Existing Conditions) are assumed to be maintained for the Future No-Build conditions. This chapter also includes potential mitigation considerations for anticipated impacts.

14.1 Assessment Methodology

Assessment Methodology for cultural and natural heritage resources was described in the ToR and refined during the Alternatives Analysis process. It has been further refined for the Proposed Project evaluation to describe potential construction and operation impacts, direct and indirect effects, and avoidance, minimisation, and mitigation considerations. For additional information, see **Section 4.6.4** of the ToR.

Many of the cultural and natural heritage resources described in this chapter are also considered in other areas of study for this EIA, including Terrestrial Ecology, Hydrology and Drainage, Socio-economics, and Noise and Vibration. The results of those analyses were used to inform the determination of minimisation of impacts and management measures, where applicable. For example, impacts to ecosystem services are described in **Chapter 13: Terrestrial Ecology**. A negative impact to a resource's ecosystem services may cause deterioration of the cultural value of that resource, whereas a positive impact may enhance the cultural value; these consequences are taken into account when analysing project impacts. To avoid overlap with other subject areas, this chapter only considers heritage aspects of the resources. Other features are described in other chapters of this ES document.

14.1.1 Applicable Standards and Guidelines

Relevant Cayman Islands laws, standards and frameworks, UK standards and guidelines, and international standards were reviewed to determine the appropriate assessment of heritage resources. The laws, policies, and standards assessed include:

14.1.1.1 Cayman Islands Laws and Standards

Cayman Islands Laws

- NT Act 2010 Revision
- NCA 2013
    - Species conservation plans
    - Management plans
- Directive for Environmental Impact Assessments 2016
- Public Lands Act 2020 Revision
- Development and Planning Act 2021 Revision

Cayman Islands Plans and Frameworks

- National Environmental Policy Framework 2002
- National Biodiversity Action Plan 2009

14.1.1.2 UK and International Standards

UK Standards and guidelines

- UK Greenbook
- UK Department for Transport "Transport Analysis Guidance" (WebTAG)
    - Unit A3 – Environmental Impact Appraisal

International Standards

- ***IFC*** **-** Performance Standards (PS)s on Environmental and Social Sustainability (2012)
    - PS 1, 6, and 8
- ***UNESCO - the International Centre for the Study of the Preservation and Restoration of Cultural Property; the International Council on Monuments and Sites; and the International Union for Conservation of Nature (UNESCO et al.)*** World Heritage Resource Manual: Guidance and Toolkit for Impact Assessments in a World Heritage Context
- ***IEMA*** **-** Principles of Cultural Heritage Impact

14.1.2 Data Sources Evaluated

14.1.2.1 Desktop Review

A desktop review of cultural and natural heritage sites was completed to identify the sites that may be impacted by the project. Resources analysed as part of the desktop review include:

- Lands protected under the NCA of 2013 (*.shp shapefile provided by the Cayman Islands DoE in November 2022)
- Lands owned by the Cayman Islands NT (*.shp shapefile provided by DoE in November 2022)
- Central Mangrove Wetland (CMW) (*.shp shapefile provided by DoE on July 19, 2023)
- Mastic Reserve and Mastic Trail (*.shp shapefile provided by DoE on July 19, 2023)
- List of parcels and inalienability status of NT lands (provided by NT on July 24, 2023)
- Cemeteries (*.shp shapefile provided by Cayman Islands NRA on July 31, 2023)
- Heritage Register (obtained from NT web database in July 2023)
- NT draft document: "Historic Built Heritage Policy Recommendations" (provided by NT during on-island meeting on July 26, 2023)

14.1.2.2 Stakeholder Consultation

On July 19, 2023, a kick-off meeting was held with the DoE and NT to discuss Terrestrial Ecology and Cultural and Natural Heritage, and on July 26, 2023, an additional meeting took place with the NT. These meetings covered data requests, study methodology, legal protection for NT sites, and heritage concerns. Details of this stakeholder consultation can be found in **Appendix E - Shortlist [Alternatives] Evaluation: Attachment G – Cultural & Natural Heritage – Assessment of Alternatives**.

14.1.2.3 Field Visit

A field verification of identified cultural and natural heritage sites took place from Monday, July 24th through Thursday, July 27th, 2023. Cultural sites that were geospatially identified were visited to validate the desktop review and establish site conditions. Details of the field visit can be found in **Appendix E - Shortlist [Alternatives] Evaluation: Attachment G – Cultural & Natural Heritage – Assessment of Alternatives**.

14.1.3 Description and Assessment of Impacts

Using the applicable standards and guidelines and the available data sources, a methodology for assessing cultural resources was established in the ToR. This methodology encompasses the "Impact Prediction" components described in the NCC EIA Directive:

> *a) The sensitivity of the environmental resource;*
> *b) The magnitude of change;*
> *c) The likelihood of the impacts occurring;*
> *d) The certainty with which impacts have been identified;*
> *e) The comparison with the do nothing / future use of site; and*
> *f) The significance of the impacts based on factors (a) – (d) above*

The methodology was refined during the Alternatives Analysis phase of the EIA using WebTAG Unit A3: Environmental Impact Appraisal. Three steps of analysis were used: 1) *establish an understanding of cultural and natural heritage resources*; 2) *identify and describe the impacts of* *the proposed project*; and 3) *assess the magnitude of the impact on identified resources*. These steps are described in the following subsections.

14.1.3.1 Establish an understanding of cultural and natural heritage resources

The first step of a heritage assessment is to identify resources and establish an understanding of those resources, including their importance, their sensitivity, and their intolerance to change. After identifying resources by examining desktop data sources, meeting with stakeholders, and conducting field evaluation, the resources were assessed based on the WebTAG tables (**Tables 14-1** and **14-2**). The resources identified and evaluated are described in **Section 14.2: Baseline Conditions**. Their importance, sensitivity, and intolerance to change are described in **Section 14.3: Project Impacts**.

Table 14-1: Importance of Resource

Importance of Resource	Criteria	Examples
Very High	High importance and rarity, international scale and limited potential for substitution	Internationally designated sites
High	High importance and rarity, national scale, or regional scale with limited potential for substitution	Nationally designated sites Regionally important sites with limited potential for substitution
Medium	High or medium importance and rarity, local or regional scale, and limited potential for substitution	Regionally important sites with potential for substitution Locally designated sites
Low	Low or medium importance and rarity, local scale	Undesignated sites of some local biodiversity and earth heritage interest
Negligible	Very low importance and rarity, local scale	Other sites with little or no local biodiversity and earth heritage interest

Source: WebTAG Unit A3, Table 8, p.77

Table 14-2: Sensitivity of Resource

Sensitivity of Resource	Criteria	Examples
Very High	High fragility or vulnerability to change, international scale. No potential for substitution	Internationally protected sites. Resource is complex or unique and has no potential for substitution.
High	High fragility or vulnerability to change, national scale. Limited potential for substitution	Nationally protected sites, unique regional sites with high fragility and complexity, and limited or no potential for substitution.
Medium	High or medium fragility or vulnerability to change, local or regional scale	Regional sites with some potential for substitution, exhibits differences between sites
Low	Low or medium fragility or vulnerability to change, local scale	Resource is relatively common and exhibits small variation between sites
Very Low	Very low fragility or vulnerability to change, no rarity, local scale	Resource is common and exhibits little variation between sites

Source: WebTAG Unit A3, section 8.2.5

The UK and international standards and guidelines recommend using qualitative evaluation matrices rather than monetising cultural or natural resources. Specifically, Unit A3 of UK's WebTAG proposes using a 7-point scale when evaluating heritage resources. Based on evaluation tables in the ToR, the Longlist Alternatives Evaluation, and reference material for this document, the following evaluation matrix (**Table 14-3**) was developed and utilised to assess each resource's intolerance to change.

Table 14-3: Intolerance to Change Scoring Matrix

Intolerance to Change		Importance of Resource				
		Very High	**High**	**Medium**	**Low**	**Very Low**
Sensitivity of Resource	**Very High**	Very High	Very High	High	Medium	Low
	High	Very High	High	Medium	Low	Very Low
	Medium	High	High	Medium	Low	Very Low
	Low	High	Medium	Low	Low	Very Low
	Very Low	Medium	Medium	Low	Very Low	Very Low

14.1.3.2 Identify and describe the impacts of the project

The next step of evaluation encompasses the possible impacts of the Proposed Project. Each potential impact was evaluated to determine whether it would be direct or indirect, negative or positive, and to establish the degree of that impact (**Table 14-4**).

Table 14-4: Criteria for Determining Impact

Impact	Criteria
Major negative	The proposal (either on its own or with other proposals) may adversely affect the integrity of the key heritage resource, in terms of the coherence of its structure and function, across its whole area, that enables it to remain for future generations.
Intermediate negative	The key environmental resource's integrity will not be adversely affected, but the effect on the resource is likely to be significant in terms of its heritage objectives.
Minor negative	Neither of the above apply, but some minor negative impact is evident.
Neutral	No observable impact in either direction.
Positive	Impacts which provide a net gain overall.

Source: WebTAG Unit A3, section 8.2.5, and Table 10, p. 81

14.1.3.3 Assess the magnitude of the impact on identified resources

After establishing a resource's Intolerance to Change and the anticipated impact, the Magnitude of Impact was evaluated through a matrix using the results of the prior two evaluations (**Table 14-5**). Additional factors, such as the likelihood of occurrence and the temporal scale of the change (where applicable) were also evaluated.

Table 14-5: Magnitude of Impact Scoring Matrix

Magnitude of impact	Intolerance to Change				
	Very high	**High**	**Medium**	**Low**	**Very Low**
Major negative	Large adverse	Large adverse	Moderate adverse	Slight adverse	Neutral
Intermediate negative	Large adverse	Large adverse	Moderate adverse	Slight adverse	Neutral
Minor negative	Slight adverse	Slight adverse	Slight adverse	Slight adverse	Neutral
Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
Positive	Large beneficial	Large beneficial	Moderate beneficial	Slight beneficial	Neutral

Source: WebTAG Unit A3, Table 11, p. 83

14.2 Baseline Conditions

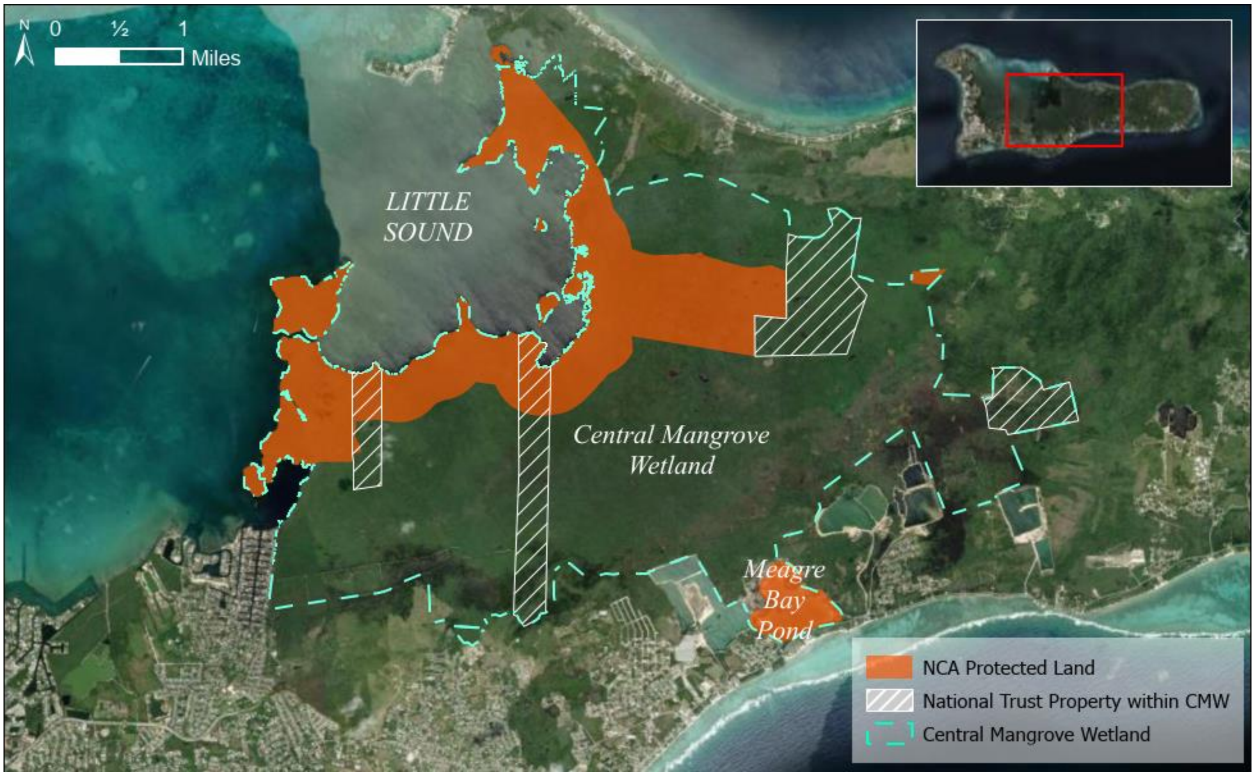
Baseline Conditions were established and examined for the EWA Longlist Alternatives Evaluation and the EWA Shortlist Alternatives Evaluation, with additional detail from more recent geospatial data and field data collection included to the Shortlist Alternatives Evaluation. The Baseline Conditions in this chapter describe resources from a cultural and natural heritage standpoint only. Also see the Terrestrial Ecology, Hydrology and Drainage, Socio-Economic, and Noise and Vibration chapters for additional discussion on aspects such as habitat quality and hydrology.

14.2.1 Central Mangrove Wetland

The CMW is an 8,655 ac (3,503 ha) ecosystem hydrologically connected to North Sound and Little Sound. Called the "ecological heart" of Grand Cayman by the NT, the CMW provides aesthetic value as a natural space, as well as providing ecosystem services like nutrient cycling that culturally important species such as fish and conch rely on to thrive (National Trust, 2022). Three species of mangrove (red, black, and white) dominate the system. This wetland provides habitat for several native birds, including the Grand Cayman Parrot. According to the Joint Nature Conservation Committee (JNCC), the CMW is a "Proposed" Ramsar Site that was identified in 2005 by the UK Overseas Territories Conservation Forum (UKOTCF) (JNCC, n.d.; UKOTCF, 2005). The Convention on Wetlands (Ramsar, Iran, 1971) or Ramsar Convention is the primary international treaty mechanism with a focus on protecting globally important wetlands; the Convention on Biological Diversity also allows for protection. Ramsar sites are known for containing rare, representative, or unique wetland types or for their importance in conserving biological diversity.

Within the CMW, 1,500 ac (607 ha) have legal protection under the NCA; much of which buffers Little Sound in north-central Grand Cayman (**Figure 14-1**). To create a CMW Reserve, the NT has been purchasing acreage in the CMW (**Figure 14-1**) over several years. To date, the NT owns 1,032 ac (418 ha) of CMW (parcel data provided by NT).

Figure 14-1: CMW Full Extent including NCA Protected Areas and NT-Owned Parcels.



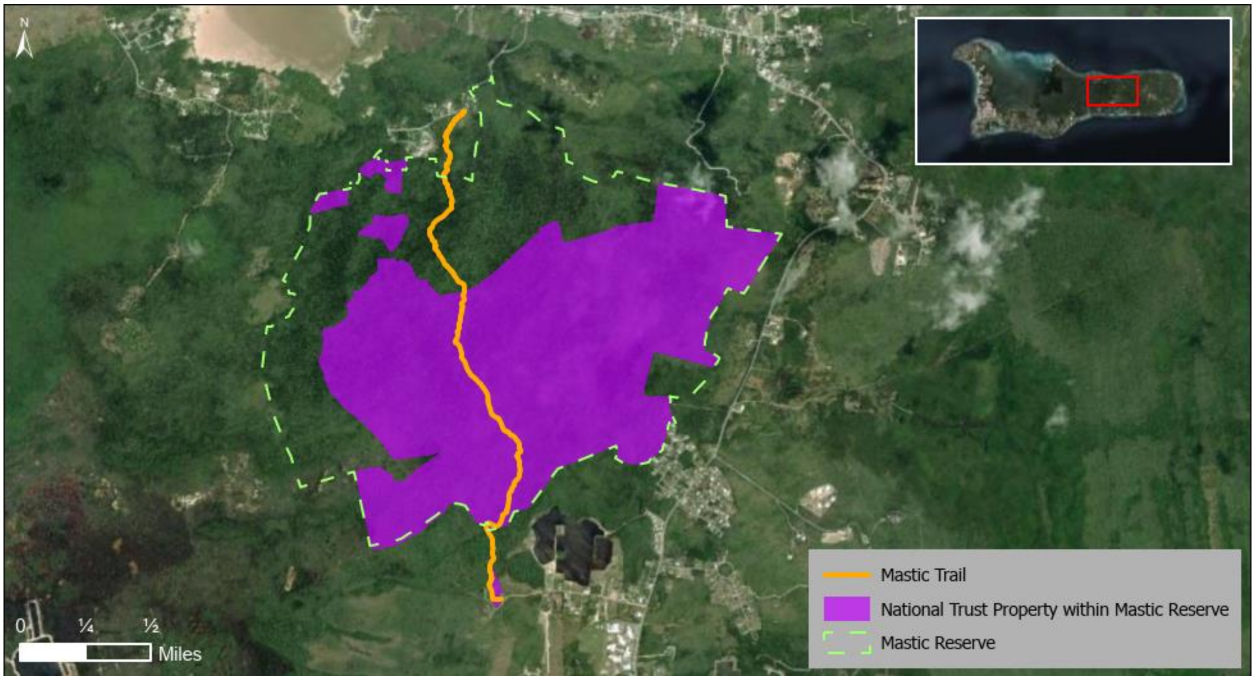
Source: DoE, Esri

14.2.2 Mastic Reserve

The Mastic Reserve, a 1,329 ac[5] (538 ha) ecosystem, is classified as "forest and woodland" by the Cayman NBAP of 2009. This ecosystem type houses several species that have contributed to the development and the identity of the Cayman Islands, including the national bird (Cayman Parrot), the national tree (Silver Thatch Palm), the national flower (Banana Orchid), and endemic species like the black mastic tree and the white-crowned pigeon. It also offers cultural importance for local and visiting naturalists as it boasts some of the most unique habitat on Grand Cayman. To date, the NT owns 46 parcels of Mastic Reserve (**Figure 14-2**), which amounts to 845 ac (342 ha) of land protected under the NT Act.

[5] Calculated geospatially with shapefile data provided by DoE.

Figure 14-2: The Mastic Reserve, Mastic Trail, and NT-Owned Parcels



Source: DoE, Esri

14.2.3 Mastic Trail

The Mastic Trail is a 2.3-mi (3.7-km) hiking trail that traverses north to south through the Mastic Reserve (**Figure 14-2**). The NT reports on its website that the Mastic Trail's history goes back further than a century, when the trail served as a major walking path that modern roads have since supplanted. In 1994, the Rotary Club located the original trail and removed forest overgrowth to restore it; in 1995, the trail was officially dedicated and opened to the public.

The Mastic Trail offers visitors a look into some of the oldest habitat on Grand Cayman and a view of culturally important species like the Banana Orchid. Guided tours of the trail can be booked via the NT. The trail is a popular hiking destination for residents and visitors to the Cayman Islands and has received write-ups in travel journals including Frommer's and U.S. News Travel (Andersen, *n.d.*, U.S. News, *n.d.*). The Mastic trail received an estimated 1,772 visitors in 2015 (Childs et al., 2015).

14.2.4 Meagre Bay Pond

Located in Bodden Town near the southern coast, Meagre Bay Pond is one of Grand Cayman's oldest protected areas. In 1976, Meagre Bay Pond and the 300 ft wide (91 m) band of mangroves around it received protection as an Animal Sanctuary. In 2013, it received designation as a protected area under the NCA. Meagre Bay Pond may meet the criteria for listing as a Ramsar Site according to local environmental organizations, though no plans exist to submit it. The southern limit of the protected area is Bodden Town Road. Meagre Bay Pond is included within the geospatial boundaries of the CMW and is recorded in the area reported for the CMW in this chapter; to the west and east are several quarries, the closest of which is directly adjacent to the NCA protected boundary.

On February 15th, 2022, the DoE's "Protected Area Management Plan for Meagre Bay Pond" was approved by the Cabinet under section 10(7) of the NCA. The Management Plan outlines constructing a small boardwalk and viewing platform to facilitate the experience of bird watchers and naturalists, and to provide educational opportunities for school groups (**Figure 14-3**). A boat launching point is planned for kayaking (possible during high water times), however the Management Plan emphasizes a limited amount of boating activity, meaning large-scale commercial operations would not be permitted.

Figure 14-3: Meagre Bay Pond Proposed Viewing Platform Location

14.2.5 Other Cultural Resources

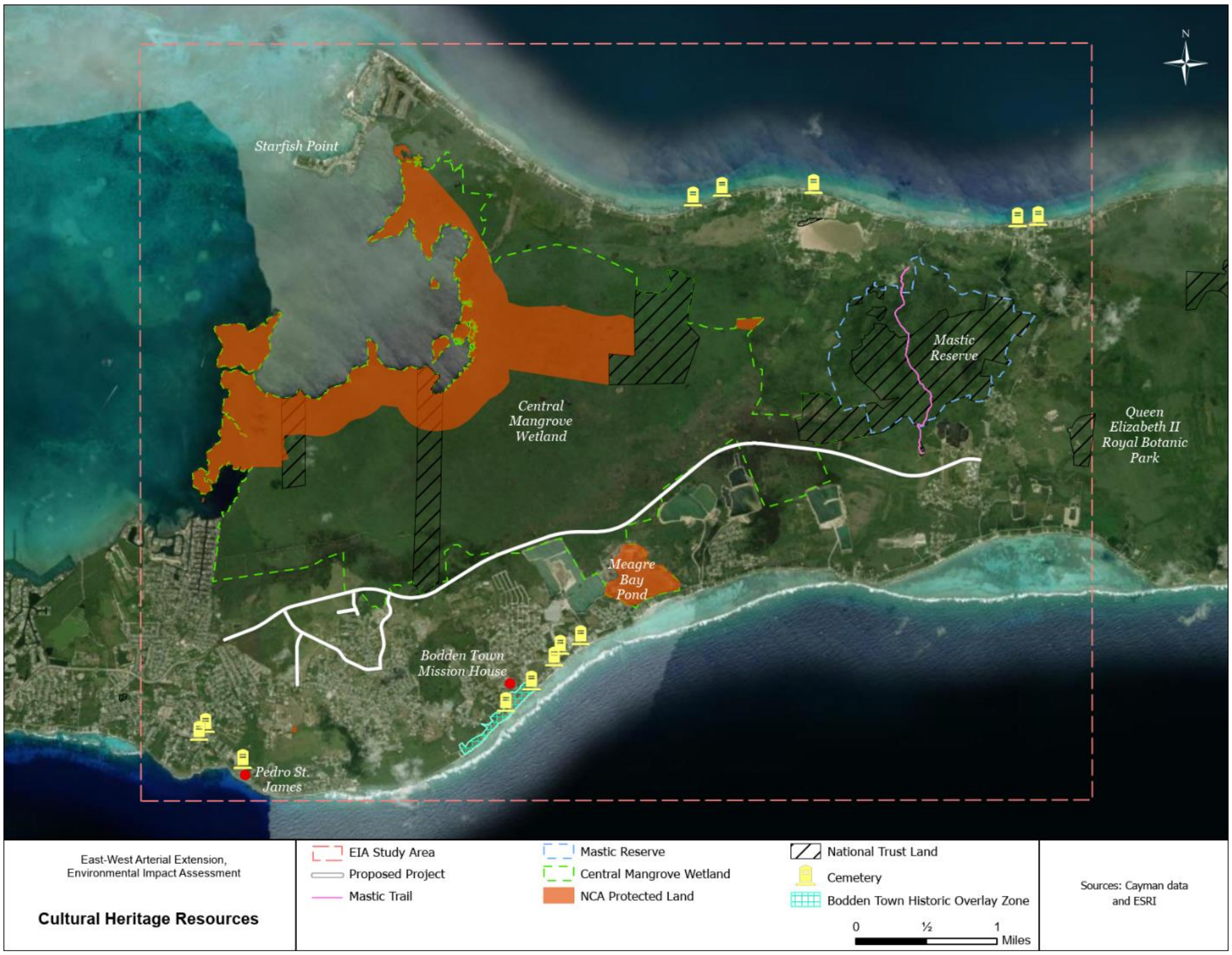
Additional cultural resources within the study area are located along Bodden Town Road and Shamrock Road, while others are located in the eastern districts. Impacts to other identified resources within the study area would not occur with the Proposed Project, and therefore they are not included in the Baseline Conditions or impact analysis. These resources are shown in **Figure 14-4,** along with the Proposed Project and the cultural heritage resources described above. They include the following:

- Cemeteries[6]
- Bodden Town Historic Overlay Zone
- Heritage Register sites

[6] Cemeteries were assessed as part of the Shortlist Evaluation due to their proximity to Alternative B4. Given the distance of the cemeteries from the Proposed Project, they have not been brought forward for evaluation in this chapter due to there being no anticipated impact to cemeteries from the Proposed Project.

- Bodden Town Mission House
- Beach Access Points
- National Attractions Authority Sites
    - Pedro St. Castle
    - Queen Elizabeth II Botanic Park
- Starfish Point

Figure 14-4: Cultural Heritage Resources within the Study Area



14.3 Project Impacts

This section describes the potential impacts to cultural and natural heritage resources that are estimated to occur as a result of the Proposed Project, either directly or indirectly through construction or operations. The Proposed Project is described in **Chapter 6: Proposed Project – Engineering Features**. **Chapter 15: Summary of Direct, Indirect, Secondary/Induced and Cumulative Effects** includes Secondary, Induced, and Cumulative impacts.

For this specific discipline, the entire mainline corridor width of 220 ft (67 m) was used to calculate potential impacts along the mainline of the Proposed Project and a width of 41 ft (12.5 m) was used for the roadway sections that are included for the Will T Connector. The estimated LOD areas surrounding the proposed intersections and access points, as well as locations with wider needs for cut or fill slopes were also included in the impact calculations.

14.3.1 Establish Understanding of Cultural and Natural Heritage Resources

14.3.1.1 Intolerance to Change: Central Mangrove Wetland

The CMW that buffers North Sound is protected under the NCA 2013. A 300 ft (91 m) buffer along the edge of Little Sound is protected under the NCA 2013. Additional parcels of the wetland are owned by the NT. Along with the NCA protected areas, the NT owns various parcels of the CMW. Public comments received during the ToR review process indicate that residents of the Cayman Islands see the CMW as a valued natural heritage resource. For these reasons, the CMW is considered a nationally designated site with limited potential for substitution, and therefore it receives a score of **"High"** rating on the Importance of Resource scale.

As the only large mangrove forest on Grand Cayman, the CMW is a unique national site with significant complexity and therefore it receives a **"High"** rating on the Sensitivity of Resource scale.

As a result of the **"High"** rating received for the previous scales, the CMW receives a **"High"** rating on the Intolerance to Change matrix.

14.3.1.2 Intolerance to Change: Mastic Reserve

The Mastic Reserve offers habitat for many important species, including the Grand Cayman Parrot. It is also culturally important as a tourism destination, as the Mastic Reserve sits on Grand Cayman's highest point and offers visitors views of exposed limestone bedrock along with views of the oldest forest ecosystem on the island. In total, 64% of the Mastic Reserve has been purchased by the NT and it has high importance and rarity on the national scale. For these reasons, the Mastic Reserve receives a rating of **"High"** on the Importance of Resource scale.

The Mastic Reserve is an ecosystem unique to the Cayman Islands. It occupies a small land area that has the highest elevation on the island with no potential for substitution. For these reasons it receives a rating of **"High"** on the Sensitivity of Resource scale.

As a result of the **"High"** rating received for the previous scales the Mastic Reserve receives a **"High"** rating on the Intolerance to Change matrix.

14.3.1.3 Intolerance to Change: Mastic Trail

The Mastic Trail is a unique local feature on Grand Cayman, offering access to view a variety of the island's natural resources. This defined trail allows people to view the ecosystem from the path rather than entering the ecosystem, and therefore helps protect the Mastic Reserve as a whole. As reported by the NT, it also contributes to Grand Cayman's history. The Mastic Trail, like the Mastic Reserve, has high national importance and rarity with limited potential for substitution. Therefore, it receives a rating of **"High"** in the Importance of Resource category.

As with the Mastic Reserve, the Mastic Trail is a unique national feature on Grand Cayman that cannot be replicated or moved. It also represents an important piece of Grand Cayman history. Therefore, in the Sensitivity of Resource category, the Mastic Trail receives a rating of **"High."**

As a result of the **"High"** rating received for the previous scales the Mastic Trail receives a score of **"High"** on the Intolerance to Change matrix.

14.3.1.4 Intolerance to Change: Meagre Bay Pond

Meagre Bay Pond is protected under the NCA 2013. Because of its status as nationally protected under the NCA and the limited potential for substitution, Meagre Bay Pond receives a rating of **"High"** on the Importance of Resource scale.

Various developments are located adjacent to Meagre Bay Pond. To the north and west of Meagre Bay Pond are several active quarries, and to the south is Bodden Town Road. The Plan describes that, due to planning error, a small amount of subdivision development occurred on portions of parcels that were within protected boundaries. The land-use encroachment into the buffer zone adds fragility to the Meagre Bay Pond area and combined with its status as a destination for birdwatching, Meagre Bay Pond receives a rating of **"High"** on the Sensitivity of Resource scale.

As a result of the **"High"** rating received for the previous scales, Meagre Bay Pond receives a **"High"** rating on the Intolerance to Change matrix.

Table 14-6: Summary Table of Resources' Intolerance to Change

Resource	Importance of Resource	Sensitivity of Resource	Intolerance to Change
CMW	High	High	High
Mastic Reserve	High	High	High
Mastic Trail	High	High	High
Meagre Bay Pond	High	High	High

14.3.2 Impact Assessment

This section describes the impacts that may potentially occur due to the Proposed Project and evaluates their potential effects on the resources previously described. The evaluation encompasses the construction and operation phases and considers whether the impact will be adverse or beneficial, the temporal and geographic scale of the impact, the intolerance to change of the resource established above, and the magnitude of impact.

14.3.2.1 Central Mangrove Wetland

The CMW receives a rating of **"High"** on the Importance of Resource scale. Direct and indirect impacts to the CMW may occur as a result of the Proposed Project. Note that impacts to the CMW as a cultural and natural heritage resource overlap with **Chapter 13: Terrestrial Ecology** and **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**. To avoid doublecounting these impacts, additional information on the CMW is provided within these other chapters.

It is anticipated that direct impacts to the CMW would occur within the area required by the Proposed Project; 75.7 ac (30.6 ha) would be directly impacted by the 2074 Proposed Project. These direct impacts would not affect any protected areas. This amount of impact area represents less than 1% of the total acreage of the CMW and therefore would not affect the overall heritage value of the resource.

Indirect impacts to the CMW could occur from habitat fragmentation, loss of hydrologic connectivity, and other hydrologic effects, which in severe enough cases could damage the natural resource's ability to function as an ecosystem. Overall, it is estimated that 571.0 ac (*231.1 ha*) of habitat could be fragmented, leaving 8,000 ac of contiguous CMW (92.4%) remaining (**Figure 14-5**). For a discussion of the Meagre Bay Pond as one of the fragmented habitats, see **Section 14.3.2.3: Meagre Bay Pond**. With these impacts, more than 90% of the resource would continue to remain intact for future generations, maintaining heritage value. Therefore, this impact is classified as a **"Minor Negative"** where the environmental resource's integrity and heritage would remain, but a minor negative impact is evident due to the fragmentation and the alterations to hydrology.

As a result, a **"Slight Adverse Impact"** to the overall heritage value of the resource would occur. The overall effects of habitat fragmentation are described in **Chapter 13: Terrestrial Ecology**. The potential hydrologic impacts that were identified are projected to have a moderate to major effect on the CMW. However, with the use of the identified mitigation considerations the CMW would be expected to maintain hydrologic connectivity and the other potential effects to this area are minimised (see **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**).

Additional potential impacts associated with the construction and operation phases of the Proposed Project, such as viewshed disruption, species with heritage value, and noise, are described in **Tables 14-7, 14-8, and 14-9**.

Figure 14-5: Central Mangrove Wetland Direct and Indirect Impacts

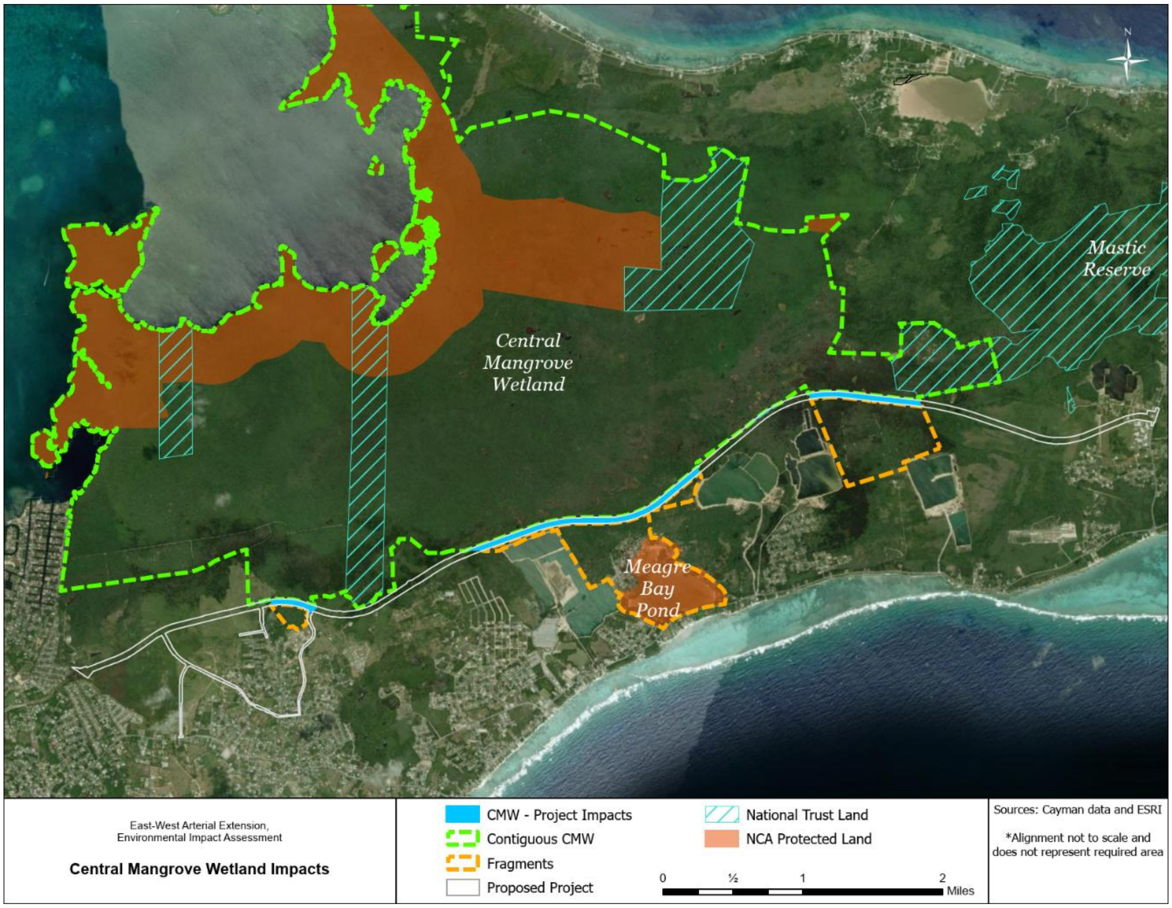


Table 14-7: Impacts on Central Mangrove Wetland Heritage

Receptor / Resource / Impact Summary	**Description / Potential Effect** *(includes likelihood and certainty)*	**Type / Temporal / Geographic**	**Intolerance to Change** ***(sensitivity x importance)***	**Degree of Impact**	**Magnitude of Impact** ***(significance)***
Construction Phase Impacts					
Loss of Heritage Value	The Proposed Project would directly impact 75.7 ac (30.6 ha) of CMW and could fragment 571.0 ac (231.1 ha) of CMW habitat as an indirect impact. 8,000 ac (3237.4 ha) of contiguous habitat (92.4 %) would remain. The heritage value of the CMW would experience a minor negative effect, as the CMW's integrity and heritage objectives would remain intact for future generations.	Adverse Long-Term Regional	High	Direct and indirect – Minor negative	Slight Adverse
Loss of Protected Property	The proposed roadway corridor initially had the potential to be constructed through property protected by NT ownership. This possibility was avoided since the roadway corridor for the Proposed Project was shifted so as not to impact NT parcels. No NCA Protected Land is within the vicinity of the Proposed Project. Therefore, direct impacts to protected property would not occur.	Adverse Long-Term Regional	High	Direct and indirect – Avoidance – None	None
Designated public access	Under the Future No-Build conditions, the CMW does not contain established public access points, trails, or viewing areas for recreational purposes. Public access points can contribute to the cultural heritage value of a resource. The Proposed Project would not increase or decrease designated public access to the CMW because it would not directly add or impact designated public access points, trails, or viewing areas. For impacts to private accessibility, please see **Chapter 15: Summary of Direct, Indirect, Secondary/Induced, and Cumulative Effects.**	Neutral Long-Term Regional	High	None	None

Receptor / Resource / Impact Summary	**Description / Potential Effect** *(includes likelihood and certainty)*	**Type / Temporal / Geographic**	**Intolerance to Change** ***(sensitivity x importance)***	**Degree of Impact**	**Magnitude of Impact** ***(significance)***
Viewshed impacts	Viewshed impacts examine the impacts to receptors (residents and residences) that enjoy natural views of the CMW. The impacts are not to the CMW itself; the intolerance to change for these receptors is therefore "low." Disruption of views due to the presence of construction equipment is possible for receptors along the Will T Connector area and at the western terminus of the Proposed Project corridor. This area has relatively flat topography with the presence of mangroves and other vegetation which would block some of the views of the Proposed Project. However, it is noted that some of the construction equipment may be taller than the vegetation in this area. Viewshed disruption would be expected for places of residence within neighbourhoods directly adjacent to the CMW and with unimpeded views of the CMW.	Adverse Short-Term Local	Low	Indirect – Minor Negative	Slight Adverse
Habitat Fragmentation	Habitat fragmentation could occur along the southern edge of the CMW. Habitat fragmentation has the potential to affect a heritage resource's integrity if it is severe enough to cause loss of ecosystem function. However, severe functional loss is not anticipated.	See **Chapter 13: Terrestrial Ecology** for additional information about important species impacts			
Important Species Impact	Habitat fragmentation may affect some species with cultural significance (e.g. Grand Cayman Parrot, mangroves). Adverse effects to species with cultural significance may contribute to affecting a heritage resource's integrity if severe enough. However, severe species impact is not anticipated.	See **Chapter 13: Terrestrial Ecology** for additional information about important species impacts			

Receptor / Resource / Impact Summary	**Description / Potential Effect** *(includes likelihood and certainty)*	**Type / Temporal / Geographic**	**Intolerance to Change** ***(sensitivity x importance)***	**Degree of Impact**	**Magnitude of Impact** ***(significance)***
Introduction of invasive species	Construction activities may have the possibility of introducing invasive species along the construction corridor for the Proposed Project within the CMW. Invasive species could compromise parts of the heritage value of the resource if they affect the ability of native species to grow and alter the composition of the ecosystem. With the use of best construction practices and the mitigation considerations identified in **Chapter 13: Terrestrial Ecology**, the introduction of invasive species is not projected to be severe and therefore would not affect the overall heritage value of the resource.	See **Chapter 13: Terrestrial Ecology** for additional information about invasive species introduction and ecosystem services			
Construction hydrological impacts	Hydrological impacts such as construction equipment releasing contaminants that pollute surface waters, changes to surface water patterns that could increase local flood risk, stormwater runoff causing erosion, or weather events causing flooding, can have a deleterious effect on the nearby natural systems. With the use of best construction practices and the mitigation considerations identified in **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** and **Chapter 13: Terrestrial Ecology**, the hydrological impacts would not severely affect the overall heritage value of the resource.	See **Chapter 13: Terrestrial Ecology** and **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** for additional information about construction contaminants and natural resources			

Receptor / Resource / Impact Summary	**Description / Potential Effect** *(includes likelihood and certainty)*	**Type / Temporal / Geographic**	**Intolerance to Change** ***(sensitivity x importance)***	**Degree of Impact**	**Magnitude of Impact** ***(significance)***
Construction noise impacts	The CMW's heritage value is not dependent on people being able to visit the resource. Therefore, while construction noise may occur adjacent to and within the CMW, there are no identified established access points, trails, or viewing areas that would be impacted by construction noise. Therefore, construction noise would not have an adverse effect on the overall heritage value of the resource.	See **Chapter 9: Noise and Vibration** for additional information about noise impacts from construction			
Operation Phase Impacts					
Viewshed impacts	Viewshed impacts examine the impacts to receptors (residents and residences) that enjoy natural views of the CMW. The impacts are not to the CMW itself; the intolerance to change for these receptors is therefore "low." A change of views due to the presence of a new road and traffic, including the potential for utility poles and a solar canopy, is possible for properties along the Proposed Project. The majority of the area identified for the Proposed Project has relatively flat topography with the presence of mangroves and other vegetation which would block some views along the Proposed Project. Changes to the overall viewshed are expected for the areas with current development.	Adverse Long-Term Localized	Low	Indirect – Minor negative	Slight Adverse

Receptor / Resource / Impact Summary	**Description / Potential Effect** *(includes likelihood and certainty)*	**Type / Temporal / Geographic**	**Intolerance to Change** ***(sensitivity x importance)***	**Degree of Impact**	**Magnitude of Impact** ***(significance)***
Traffic Noise	The CMW's heritage value is not dependent on people being able to visit the resource. Therefore, while traffic noise may occur adjacent to and within the CMW, there are no established access points, trails, or viewing areas that would be impacted by traffic noise. Therefore, traffic noise would not have an adverse effect on the overall heritage value of the resource.	See **Chapter 9: Noise and Vibration** for additional information			
Hydrologic effects	Long-term alterations to hydrology have the potential to affect the functionality of the resource, which would in turn affect the heritage value of the resource. These impacts have the possibility of causing moderate to major disruptions to the ecosystem. With the use of the mitigation considerations identified in **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**, the hydrologic effects are not projected to affect the overall heritage value of the CMW.	See **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** for additional information			

14.3.2.2 Mastic Reserve and Mastic Trail

Direct impacts to the Mastic Reserve and Mastic Trail are not projected to occur as a result of the Proposed Project, so this following section discusses indirect impacts only. These effects are described in **Table 14-8**.

As previously described, the Mastic Reserve and Mastic Trail have an Intolerance to Change rating of **"High."** However, the trail's ability to accommodate visitors is less sensitive and will tolerate change more readily than the Reserve as a whole, due to the fact that the trail is designed to be used by humans and has been open to the public since 1995. Therefore, the Mastic Trail receives an intolerance to change score of **"Medium"** when considering correct footpath usage.

Table 14-8: Impacts on Mastic Reserve and Trail Heritage

Receptor / Resource / Impact Summary	**Description / Potential Effect** *(includes likelihood and certainty)*	**Type / Temporal / Geographic**	**Intolerance to Change** ***(sensitivity x importance)***	**Level of Impact**	**Magnitude of Impact** ***(significance)***
Construction Phase Impacts					
Construction Noise	There is the potential for noise from construction of the eastern portion of the roadway.	See **Chapter 9: Noise and Vibration** for additional information.			
Operation Phase Impacts					
Additional visits from residents and tourists / access to site	The Proposed Project would provide a new transportation route to reach the Mastic Trail and as a result, additional visits from residents and tourists wishing to experience the trail are possible. This additional use would further promote this heritage resource. Specific information on travel times to and from the area of the Mastic Trail can be found in **Chapter 8: Socio-Economics**.	Beneficial Long-Term National	Medium	Indirect - Positive	Moderate Beneficial
Noise impacts from traffic using the Proposed Project	Comparing the 2074 Core Build to the 2026 No-Build, the noise receptors near the Mastic Trail would be anticipated to experience a major increase (greater than 10 decibels) in predicted noise levels. However, the Mastic Trail noise levels are predicted to remain below the SOAEL.	See **Chapter 9: Noise and Vibration** for additional information.			
Hydrologic Impacts	The Proposed Project may influence water flow, water levels, and drainage patterns connected to the Mastic Reserve. With the use of the mitigation considerations identified in **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**, such as the installation of a localised drainage system, the potential impacts would be of moderate significance and would not affect the overall heritage value of the Mastic Trail or the Mastic Reserve.	See **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** for additional information			

14.3.2.3 Meagre Bay Pond

Direct impacts to Meagre Bay Pond as a result of the Proposed Project are not projected to occur, therefore this section discusses indirect impacts only. As previously described, Meagre Bay Pond has an Intolerance to Change rating of **"High."** However, Meagre Bay Pond's ability to accommodate visitors is less sensitive and will tolerate change more readily than Meagre Bay Pond as a whole, due to the fact that Meagre Bay Pond is a known bird-watching location which accommodates visitors from its banks. Therefore, Meagre Bay Pond receives an intolerance to change score of **"Medium"** when considering usage as a bird- and nature-watching area.

Hydrologic effects to Meagre Bay Pond have the potential to impact its heritage value. Effects such as hydrologic dysconnectivity, pollution, and erosion may alter the water budget of Meagre Bay Pond and the connected wetland. Severe impacts to water budget and therefore to the ecosystem functionality could affect the heritage value of Meagre Bay Pond by reducing the number and/or species of birds that visit Meagre Bay Pond. These effects have the potential to occur during both the construction and operations phases of the Proposed Project. Additional effects may also include habitat fragmentation (separation of Meagre Bay Pond from the greater CMW), noise impacts, and accessibility. These effects are described in **Table 14-9**.

Table 14-9: Impacts on Meagre Bay Pond Heritage

Receptor / Resource / Impact Summary	Description / Potential Effect *(includes likelihood and certainty)*	Type / Temporal / Geographic	Intolerance to Change *(sensitivity x importance)*	Level of Impact	Magnitude of Impact *(significance)*
Construction Phase Impacts					
Hydrologic effects	Hydrologic effects due to construction could occur, such as drainage/flooding, pollution, erosion/runoff, and soil issues. These effects have the potential to create impacts ranging from minor to major significance. With the use of the mitigation considerations identified in **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**, these possible hydrologic effects are not anticipated to affect the overall heritage value of the resource.	See **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** for additional information			

Receptor / Resource / Impact Summary	**Description / Potential Effect** *(includes likelihood and certainty)*	**Type / Temporal / Geographic**	**Intolerance to Change** ***(sensitivity x importance)***	**Level of Impact**	**Magnitude of Impact** ***(significance)***
Operation Phase Impacts					
Additional visits from residents and tourists / access to site	As a result of the Proposed Project, it is projected that there would be a decrease in traffic volume and less traffic congestion along Bodden Town Road when compared with the Future No-Build scenario. Bodden Town Road provides the main access point to Meagre Bay Pond. With lower traffic volume and lower traffic congestion, additional visits from residents and tourists wishing to visit Meagre Bay Pond are possible, thus promoting this heritage resource.	Beneficial Long-Term Localized	Medium	Indirect - Positive	Moderate Beneficial
Improper use of viewing area and pond	Due to the potential for increased number of visitors, improper use of the resource (e.g. boating during unsuitable times, traversing away from viewing platform) may also increase.	Adverse Long-Term Localized	Medium	Indirect – Minor Negative	Slight Adverse
Habitat Fragmentation	Due to the location of the Proposed Project Meagre Bay Pond would not be directly contiguous to the CMW habitat. However, Meagre Bay Pond is considered a separate cultural resource from the CMW. Therefore, the placement of the Proposed Project would not affect its cultural value.	See **Chapter 13: Terrestrial Ecology** for additional information.			

Receptor / Resource / Impact Summary	Description / Potential Effect *(includes likelihood and certainty)*	Type / Temporal / Geographic	Intolerance to Change *(sensitivity x importance)*	Level of Impact	Magnitude of Impact *(significance)*
Alterations to hydrology (including connectivity to CMW)	The presence of the Proposed Project could potentially alter the hydrological connection between Meagre Bay Pond and the CMW. Hydrology alterations could result in loss of heritage value if they are damaging to the resource. As a result of the Proposed Project Meagre Bay Pond could experience a hydrologic disconnect from the CMW. With the use of the mitigation considerations identified in **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**, including the use of bridging, hydrologic flow could possibly be maintained.	See **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** for additional information about hydrological connectivity between resources			
Noise impacts from traffic alterations along Bodden Town Road	Meagre Bay Pond is located along the existing roadway network and already experiences noise at a SOAEL at the viewing platform under the 2026 No-Build condition. The Proposed Project is anticipated to provide a noise benefit (reduction) in 2026.	See **Chapter 9: Noise and Vibration** for additional information.			

14.4 Mitigation Measures

Because many direct and indirect impacts to the Cultural and Natural Heritage Resources overlap with other disciplines, mitigation considerations for non-tourism-related impacts to these resources are also described in other discipline chapters within this ES. **Table 14-10** below describes the characterisations used to evaluate the impacts after mitigation considerations have been applied.

Table 14-10: Impact Analysis Factors

Characterisation	Description	Quantitative Measure or Definition of Qualitative Categories
Magnitude	The size or degree of the effects compared against baseline conditions or reference levels, and other applicable measurement parameters (i.e., standards, guidelines, objectives)	**Negligible (N) |** Differing from the average baseline conditions to a very small degree, but within the range of the natural variation **Very Low (VL) |** Differing from the average baseline conditions to a small degree, but very minimally out of the range of the natural variation **Low (L) |** Differing from the average baseline and outside the range of natural variation but less than or equal to appropriate guideline or threshold value **Medium (M) |** Differing from the average baseline and outside the range of natural variation and marginally exceeding a guideline or threshold value **High (H) |** Differing from the average baseline and outside the range of natural variation and exceeding a guideline or threshold value
Geographic Extent	The geographic area over which the effects are likely to be measurable	**Limits of Disturbance (LOD) |** Occurs within the Proposed Project LOD **Outside Limits of Disturbance (OLOD) |** Occurs outside of the Proposed Project LOD, but within the identified Study Area
Timing	Considers when the environmental effect is expected to occur. Timing considerations are noted in the evaluation of the environmental effect, where applicable or relevant.	**Not Applicable (NA) |** Seasonal variations are not likely to change the effect **Applicable (A) |** Seasonal aspects may affect the outcome of the effect
Duration	The time period over which the effects are likely to last	**Short-Term (ST) |** The effect is reversible at the end of construction works **Medium-Term (MT) |** The effect is reversible within a defined length of time **Long-Term (LT) |** The effect is reversible over an extended length of time
Frequency	The rate of recurrence of the effects (or conditions causing the effect)	**Once (O) |** Effects occur once **Occasional (Oc) |** Effects that could occur randomly throughout the project lifetime **Regular (R) |** Effects can occur at regular intervals through construction and/or operation **Continuous (C) |** Effects are continuous throughout construction and operation

Characterisation	Description	Quantitative Measure or Definition of Qualitative Categories
Reversibility	The degree to which the effects can or will be reversed (typically measured by the time it will take to restore the environmental attribute or feature)	**Reversible (R) |** The baseline conditions will recover to their standard after the construction works are completed **Partially Reversible (PR) |** Mitigation can return the baseline conditions **Not Reversible (NR) |** Mitigation cannot guarantee a return to baseline conditions

14.4.1 Construction Phase

Mitigation considerations for construction phase impacts to natural heritage resources (CMW, Mastic Trail, Mastic Reserve, Meagre Bay Pond) are also described within other chapters of this ES document. Descriptions of these potential construction phase mitigation considerations are provided in **Table 14-11**.

Table 14-11: Construction Phase Mitigation Considerations for Cultural and Natural Heritage Resources

Resource	Potential Effect	Mitigation Measure Considerations
CMW, Mastic Trail, Mastic Reserve, Meagre Bay Pond – Terrestrial Effects	Temporary loss of heritage value of CMW, Meagre Bay Pond, Mastic Reserve, and Mastic Trail due to terrestrial impacts during construction.	See **Chapter 13: Terrestrial Ecology** for construction sequencing and mitigation methods. Applicable avenues of mitigation could include refining the roadway design to minimise the footprint and avoid high-quality habitat, clear demarcation to avoid unnecessary vegetation clearing, invasive species control, and replanting of areas disturbed during construction.
CMW, Mastic Trail, Mastic Reserve, Meagre Bay Pond – Hydrology effects	Temporary loss of heritage value of CMW, Meagre Bay Pond, Mastic Reserve, and Mastic Trail due to hydrology impacts during construction.	See **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** for more information. Applicable avenues of mitigation could include: • Inspection/management of construction equipment • Development/implementation of Stormwater Pollution Prevention Plan • Limiting activities that contribute to erosion and runoff
Mastic Trail, Mastic Reserve, Meagre Bay Pond – Noise effects	Temporary loss of heritage value due to noise impacts during construction.	See **Chapter 9: Noise and Vibration** for more information. Applicable avenues of mitigation could include: • Training of site personnel • Provision of information to the public • Noise-reducing construction methods • Temporary barriers • Time-frame restrictions • Noise insulation for homes

14.4.2 Operations Phase

During operation of the Proposed Project, mitigation measures can be considered to reduce impacts on and off-site. The following describes potential mitigation measure considerations that could be used to aide in addressing the impacts to cultural and natural heritage resources previously described. Descriptions of these operations phase mitigation considerations are provided in **Table**

14-12. Mitigation considerations for cultural and natural heritage resources are also described within other chapters of this ES document.

Table 14-12: Operation Phase Mitigation Considerations for Cultural and Natural Heritage Resources

Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Mastic Trail / Meagre Bay Pond	Wear and tear on public access points to heritage resources due to additional tourist visits.	Mitigation of additional resident and tourist access to cultural heritage resources via tourist education materials, proper trail markers, guided tours, and informational signage.	VL	OLOD	NA	LT	C	PR	None	Not significant
			Assuming mitigation measures are applied, there would be very low impacts to the site. Effects of visitors would occur outside the LOD. Weather patterns may alter when people choose to visit the heritage sites, but tourists visit the island year-round, so seasonal changes are not anticipated. Any effects caused by additional visitors would occur over the life of the heritage resource. Any effects caused by additional visitors would occur continuously after construction is completed. Mitigation would offset the impacts of additional visitors to maintain current baseline conditions							
CMW, Mastic Trail, Mastic Reserve, Meagre Bay Pond – Hydrology effects	Loss of heritage value of CMW, Meagre Bay Pond, Mastic Reserve, and Mastic Trail due to hydrologic effects	See **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** for more information. Applicable avenues of mitigation could include: • Inclusion of localized drainage systems and opening structures under the Proposed Project Drainage infrastructure and stormwater management • Roadway openings designed to maintain flow • Treatment of roadway runoff and erosion protection								
CMW, Mastic Trail, Mastic Reserve, Meagre Bay Pond – Terrestrial effects	Loss of heritage value of CMW, Meagre Bay Pond, Mastic Reserve, and Mastic Trail due to terrestrial ecology effects.	See **Chapter 13: Terrestrial Ecology** for additional information. Applicable avenues of mitigation could include: • Avoidance of direct impacts • Visual/viewshed screening • Invasive species control • Land conservation within the corridor • Replanting temporary impact areas • Enhancement of areas within wildlife corridor • Environmental education								

Resource	Potential Effect	Mitigation Measures	Magnitude	Geographic Extent	Timing	Duration	Frequency	Reversibility	Residual Effect	Significance of Residual Effect
Mastic Trail, Mastic Reserve, Meagre Bay Pond – Noise effects	Loss of heritage value of CMW, Meagre Bay Pond, Mastic Reserve, and Mastic Trail due to noise and vibration effects	See **Chapter 9: Noise and Vibration** for additional information. Applicable avenues of mitigation could include noise reduction measures that could be explored during the Detailed Design phase (outside of the EIA process).								

14.4.3 Summary of Cultural and Natural Heritage Mitigation Measure Considerations

Any minor adverse impacts associated with increased cultural and natural heritage site visits from tourists can be adequately mitigated for to reduce the impact to an insignificant level. Mitigation considerations to alleviate wear and tear on heritage resources would not be required during the design and construction phase. During the operation phase, mitigation measures would include:

- Tourist education materials.
- Proper trail markers.
- Guided tours.
- Informational signage.

Most impacts to cultural and natural heritage resources from the Proposed Project are covered in other chapters of this ES, including **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**, **Chapter 13: Terrestrial Ecology**, and **Chapter 9: Noise and Vibration**. A loss of heritage value is based on overall impacts to a resource combined with the public perception of that resource. Therefore, mitigation considerations applied to other resources could have a beneficial effect on the cultural and natural heritage values of those resources as well. While data is not available to quantify public perception of heritage loss of these Caymanian resources, mitigation considerations would ameliorate the impacts to these resources and allow the heritage value to remain intact for generations to come.

As described in **Chapter 13: Terrestrial Ecology**, mitigation considerations for the CMW and important species habitat would include elements such as:

- Avoidance of direct impacts
- Visual/viewshed screening
- Invasive species control
- Land conservation within the corridor
- Replanting temporary impact areas
- Enhancement of areas within wildlife corridor

- Environmental education

As described in **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**, mitigation considerations for overall hydrologic connectivity, which benefits the CMW, the Mastic Reserve, and the Freshwater Lenses, would include elements such as:

- Inclusion of localized drainage systems and opening structures under the Proposed Project Drainage infrastructure and stormwater management
- Roadway openings designed to maintain flow
- Treatment of roadway runoff and erosion protection

As described in **Chapter 9: Noise and Vibration**, mitigation considerations could include noise reduction measures that could be explored during the Detailed Design phase, which would be outside of the EIA process.

Additional information regarding implementation, responsibilities for implementation, any monitoring and reporting, and actions for non-compliance will be included as part of the separate EMP. Due to the phased development of the project, a review of the mitigation measures and design solutions will be continually evaluated during the design, construction, and operation phases to allow for successful mitigation. If the mitigation measure considerations are not implemented, the Slight Adverse impact to cultural and natural heritage sites (**Section 14.3.2: Impact Assessment**) would remain.

15 Summary of Direct, Indirect, Secondary/Induced, and Cumulative Impacts

The purpose of this chapter is to provide a summary of the direct, indirect, secondary/induced, and cumulative impacts for the Proposed Project. **Table 15-1** provides definitions of the impact terminology. The term "effect" and "impact" are used synonymously in the referenced materials and in this chapter. Direct and indirect impacts are related to the construction and operation of the Proposed Project and have been evaluated and described in more detail in **Chapters 8** through **14**. Secondary/induced and cumulative impacts incorporate potential impacts from other independent projects that have been estimated to occur within the study area and which have been described in **Chapter 7: Transportation and Mobility** and **Chapter 8: Socio-Economics**.

Table 15-1: Impact Terminology Definitions

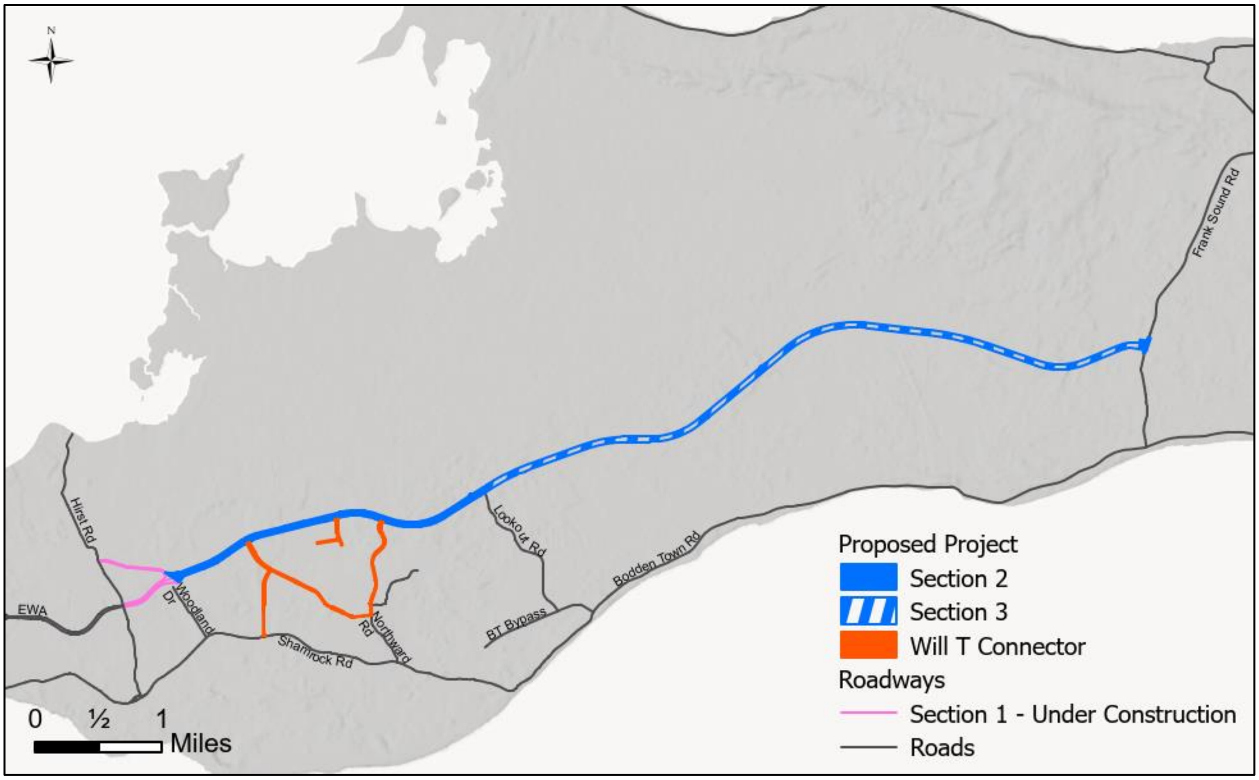
	Direct*	Indirect*	Secondary/Induced	Cumulative
Nature of Impact	Typical/ Inevitable/ Predictable	Reasonably Foreseeable/ Probable	Reasonably Foreseeable/ Probable	Reasonably Foreseeable/ Probable
Cause of Impact	Construction or Operation of EWA Extension corridor	Construction or Operation of EWA Extension corridor	New land development that occurs after a project is built	Summation of previous three categories (Direct, Indirect, Secondary/Induced)
Location	At project location (EWA corridor LOD)	Within the boundaries of the system affected by the project (EIA study area)	Within the boundaries of the system affected by the project (Secondary/Induced Growth study area)	Within the boundaries of the system affected by the project (EIA study area)
Example from Reference Materials	"*Examples of common direct effects for transportation projects include residential and business displacements, the fill of wetlands to construct a roadway, or the removal of a historic structure*." (AASHTO, 2016)	"*An example of an [indirect] encroachment effect is a long-term decline in the viability of a population of a particular species as a result of habitat fragmentation caused by the project*." (AASHTO, 2016)	"*Induced growth refers to new land developments that occurs after a project is built. To be considered induced growth, this growth would not happen if the project were not built*." (FHWA, 2018)	"*Incremental noise from a number of separate developments*" (NCC, 2016) "*the cumulation of effects with other existing and, or approved projects, taking into account any existing environmental problems relating to areas of particular environmental importance likely to be affected or the use of natural resources*" (Planning Inspectorate, 2024)

** Impacts in these categories often overlap and boundaries blur. The categorization is not important as long as the NEPA [EIA] document demonstrates that the [indirect] effects have been considered (AASHTO, 2016).*

15.1 Direct Impacts

Direct impacts are typical/inevitable/predictable, occur at the time of the project construction or operation, occur at the project location, and are caused by the project. The Study Area for direct impacts is comprised of the estimated Proposed Project LOD, which includes Section 2, Section 3, and the Will T Connector (**Figure 15-1**).

Figure 15-1: Proposed Project Limits of Disturbance (LOD)



Highlights of the potential direct impacts identified for the Proposed Project are summarized in **Table 15-2**. Direct and indirect impacts of a project overlap and the distinction can be blurred; however, the categorisation is not important if the potential impacts are evaluated as part of the document (AASHTO, 2016). As part of the EIA, direct impacts were considered to be within the Proposed Project LOD. A summary of the quantifiable values from a sample of the key elements studied is summarized in **Table 15-2**. Indirect impacts are described in **Section 15.2: Indirect Impacts** where potential indirect impacts of the Proposed Project are estimated. Additional details and descriptions of the estimated direct and indirect impacts can be found in **Chapters 8** through **14**.

Table 15-2: Potential Direct Impacts of the Proposed Project

Notable Feature	Proposed Project Impact (Imperial)	Proposed Project Impact (Metric)
Natural Environment		
Man-modified land uses	90.08 ac	36.45 ha
Upland Habitats	5.34 ac	2.16 ha
Wetland Habitats	150.24 ac	60.8 ha
Cayman Parrot Habitat	80.7 ac	32.7 ha
Functional Loss*	103.66-189.31 functional units	
Central Mangrove Wetland	76 ac	31 ha
Impervious Surface Area	145 ac	59 ha
Potentially Affected Drainage Wells	1 drainage well	1 drainage well
Lower Valley Freshwater Lens Recharge Area	10.3 ac	4.2 ha
Peat Removal	441,579 cubic yds	337,612 m^3
Social Environment		
Relocations	3 structures	3 structures
ROW	249.14 ac	100.86 ha
Noise Sensitive Receptor Impacts (noticeable increase)	963 receptors	963 receptors
Noise Sensitive Receptor Impacts (above SOAEL**)	279 receptors	279 receptors

**See Chapter 13-Terrestrial Ecology for additional details regarding functional loss. Functional loss takes into account the hydrologic connection, uniqueness, location, and fish and wildlife utilisation of a habitat.*

***Significant Observed Adverse Effect Level*

15.2 Indirect Impacts

Indirect impacts are reasonably foreseeable/probable, generally happen at some future time other than direct impacts, are located within the bounds of systems affected by the project (EIA Study Area) and are caused by the project's direct impacts. The Study Area for indirect impacts is the EIA Study Area shown in **Figure 15-2**. Potential indirect impacts identified for the Proposed Project are summarized within this section. Additional details and descriptions of indirect impacts can be found in **Chapters 8** through **14**.

Figure 15-2: EIA Study Area

15.2.1 Natural Environment

The estimated potential indirect impacts of the Proposed Project, which are reasonably foreseeable/probable, related to the natural environment include:

- Change of surface water flows and drainage patterns/flood risk
- Surface water pollution potential
- Subsurface impacts
- Habitat fragmentation
- Wildlife/roadway collisions
- Noise

- Light pollution
- Spread of invasive species

15.2.1.1 Change of Surface Water Flows and Drainage Patterns/Flood Risk

The Proposed Project may change surface water flows and drainage patterns and locally increase flood risk for the CMW, Mastic Reserve, Meagre Bay Pond, and Freshwater Lenses. Impacts may occur temporarily during construction by elements such as temporary storage and stockpiling of materials and during long-term operation by elements such as an increase of stormwater runoff volume and velocity from impervious surfaces (pavement).

The Proposed Project traverses delicate habitat with important baseline flow patterns, such as the natural flushing of the Meagre Bay Pond into the CMW and the fresh/salt water hydrologic gradients in the CMW. The Proposed Project has the potential to alter these flow patterns and cause impacts to the natural resources that they serve. Based on the concept level hydrology studies, the slight differences in floodwaters shown for the CMW and for the other natural resources within the Study Area were not considered significant for the 50-year storm that was utilised for this analysis.

The loss of mangroves reduces transpiration, which may increase runoff and could reduce floodplain roughness, thereby potentially increasing run-off velocity and reducing protection from tropical storms and hurricanes. In addition, the removal of or drowning of mangroves may decrease precipitation on the western end of the island. See **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** for additional details.

15.2.1.2 Surface Water Pollution Potential

The operations from the Proposed Project have the potential to release contaminants that may potentially pollute sensitive habitats and the underlying aquifers. Contaminants may consist of toxic metals, suspended solids, and hydrocarbons and can be deposited onto the road from vehicle leaks, such as crankcase oil, transmission, hydraulic and brake fluid, antifreeze and gasoline. Contaminants can be released directly (e.g., spillages) or indirectly (via surface water runoff). See **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** for additional details.

15.2.1.3 Subsurface Impacts

The Proposed Project may change the subsurface environment within the Study Area, including freshwater lenses, brackish groundwater, and peat. The potential indirect impacts during construction include pollution and compaction from construction equipment and activities, including dewatering. Potential contaminants (listed in **Section 15.2.1.2**), have the potential to reach the subsurface environment.

The freshwater lenses within the Study Area may experience changes in groundwater flow patterns, including disrupted hydrological regimes and reduced groundwater recharge and flow. This could result in freshwater lens shape, configuration, and discharge flow direction changes. The freshwater lenses may also inadvertently drain into underlying karst formations or experience a local drop in the water table if infiltration were reduced by new impermeable surfaces. See **Chapter 11: Geo-Environmental** for additional details regarding freshwater lenses and peat.

15.2.1.4 Habitat Fragmentation

Habitat fragmentation occurs when a large area of habitat is divided into small, isolated areas. The resulting smaller habitat areas may be too small for some species to continue to use the area. The action that results in the habitat fragmentation could also create a barrier restricting species movement between habitat area, as with roadways. As the Proposed Project is a new roadway that would traverse undeveloped land, habitat fragmentation is expected to occur. The CMW is the main habitat the Proposed Project would impact through fragmentation. The Proposed Project was specifically designed to be located along the edge of development on the southern edge of the CMW in order to minimise the magnitude of habitat fragmentation. Overall, it is estimated that 571 ac (231 ha) of habitat could be fragmented, leaving an estimated 8,000 ac (3,238 ha) of contiguous CMW (92.4%) remaining. See **Chapter 13: Terrestrial Ecology** for additional details regarding habitats.

15.2.1.5 Wildlife/Roadway Collisions

As discussed above, a new road can split through a habitat area. The species that use that habitat may be deterred from crossing the road, however, some may not. Collisions with these species are inevitable unless measures are taken to reduce the risk. See **Chapter 13: Terrestrial Ecology** for additional details regarding habitats and animals.

15.2.1.6 Noise

Noise generated from roadways can cause negative impacts to wildlife, such as behavioural changes, communication difficulties, reduced hunting areas, stress, migration changes, cognitive problems, and physiological stress. Some animals are able to acclimate to changes in the noise environment, while others may not be able to. See **Chapter 9: Noise and Vibration** for additional details regarding predicted noise levels.

15.2.1.7 Light pollution

Lighting from roadways and from vehicles traveling at night can cast light into habitat that is usually dark at night. This can have several negative effects on the species within the habitat including, but not limited to, disorientation, disruption to the circadian rhythm, and increased road mortality by species, or their prey, being attracted to lighting. At this stage, the lighting for the Proposed Project is conceptual. However, light fixtures and luminaires that reduce the impact of night-time lighting on the surrounding habitats can be considered during the detailed design phase. See **Chapter 6: Proposed Project: Engineering Features** for additional details regarding design elements.

15.2.1.8 Spread of Invasive Species

Invasive species are species that have been introduced to places outside of their natural range that have negative impacts on the native biodiversity. Invasive flora often thrive in disturbed land and along roads. These species compete, and often outcompete, with native species for resources. Successful invasive flora can take over a site and alter the surrounding ecosystem and food web. Invasive flora found on Grand Cayman includes, but is not limited to, Brazilian pepper (*Schinus terebinthifolia*), wild tamarind (*Leucaena leucocephala*) and Australian pine (*Casuarina equisetifolia*). The former two species thrive in disturbed areas and quickly outcompete native flora. See **Chapter 13: Terrestrial Ecology** for additional details regarding invasive species.

15.2.2 Social Environmental

Potential indirect impacts of the Proposed Project, which are reasonably foreseeable/probable, related to the social environment include:

- Accessibility Improvements
- Intersection Delays
- Changes to Development
- Severance
- Journey Quality Improvements
- Option Value Improvements
- Flooding in Developed Areas
- Viewshed
- Noise and Vibration
- Local Workforce Utilisation
- Construction Traffic Disruptions

15.2.2.1 Accessibility Improvements

Accessibility impacts evaluated the comparison of the Proposed Project to the No-Build condition. It was estimated that the Proposed Project would have a beneficial impact on the ability to access goods and services across the island, specifically for Bodden Town, East End and North Side residents. The amount of time traveling from eastern to western districts would be reduced and a greater number of east - west trips could be accommodated. The number of jobs available to residents of the eastern districts would increase. More people would have the ability to access emergency services in western districts if Bodden Town Road is closed or obstructed. Additional tourist visits to eastern sites would be possible, bringing additional spending to those facilities and nearby local businesses, and enhancing the cultural value of those tourist sites. See **Chapter 7: Transportation and Mobility**, **Chapter 8: Socio-Economics** and **Chapter 14: Cultural and Natural Heritage** for additional details.

15.2.2.2 Intersection Delays

Impacts from the Proposed Project are expected to degrade intersection delay at the intersections of Bodden Town Road at Frank Sound Road, Frank Sound Road at Clifton Hunter High School, and EWA at Agricola Drive Connector. The Proposed Project negatively impacts these three intersections based on LOS criteria due to an increase in traffic demand and volumes. Additional improvements will be added to the project in the future to mitigate these impacts, including traffic signals, additional turn lanes, and a multilane roundabout with bypass lanes. These improvements are not included in the EWA Proposed Project. See **Chapter 7: Transportation and Mobility** for additional details.

15.2.2.3 Changes to Development

The improved accessibility could lead to both positive and negative impacts based on subject area and view of the impact due to changes in development within the Study Area. See **Section 15.3 Secondary/Induced Impacts** for discussion of induced demand, induced development, and land use development propensity forecasting.

15.2.2.4 Severance

While there is the potential for severance, the provisions for bicycle and pedestrian travel could reduce severance due to the increased mobility options for walking, biking, and other micromobility transportation modes. Overall, the Proposed Project is estimated to have a beneficial effect on severance. See **Chapter 8: Socio-Economics** for additional details.

15.2.2.5 Journey Quality Improvements

The Proposed Project would offer an improvement in natural views during east-west journeys, would contribute to lower driver frustration due to a higher number of intersections operating at an acceptable LOS, and would reduce conflict points due to bypassing developed areas, which could reduce driver fear of potential accidents. See **Chapter 8: Socio-Economics** for additional details.

15.2.2.6 Option Value Improvements

The Proposed Project would offer safer non-vehicular travel options between eastern and western districts when compared with existing options. See **Chapter 8: Socio-Economics** for additional details.

15.2.2.7 Flooding in Developed Areas

As previously described for the natural environment areas, the results of the hydrology analysis estimate that there would be a slight decrease in the peak water level due to the Proposed Project; however, the study also showed that, on average, the water in the identified developed areas is impounded for longer than Baseline Conditions. These conditions suggest that, while the Proposed Project is generally not impactful when considering peak water surface elevations, the configuration of the roadway and the associated openings are estimated to result in longer drain times for the water that would be impounded. Based on the concept level hydrology studies, the slight differences in floodwaters shown for the developed areas are within acceptable tolerances for the scale of storms being considered. See **Chapter 12: Hydrology and Drainage, Including Climate Resiliency** for additional details.

15.2.2.8 Viewshed

A change of views, due to the presence of a new road and traffic, including the potential for utility poles, a solar canopy and lighting, is possible for properties along the Proposed Project. The majority of the area identified for the Proposed Project has relatively flat topography with the presence of mangroves and other vegetation which would block some views along the Proposed Project. Changes to the overall viewshed are expected for the areas with current development. See **Chapter 14: Cultural and Natural Heritage** for additional details.

15.2.2.9 Noise and Vibration

Noise and vibration can be both a direct and indirect impact to the social environmental. In addition, the operational noise impacts discussed in **Section 15.1: Direct Impacts**, temporary increases in local noise levels due to construction (e.g. equipment, delivery vehicles, commuting crew members) may be experienced by sensitive noise receptors within the noise study area. Construction may also result in temporary vibration impacts that are perceptible and annoying to the population closest to the source. See **Chapter 9: Noise and Vibration** for additional details regarding predicted noise levels and vibration screening distances.

15.2.2.10 Local Workforce Utilisation

The project could utilise a local workforce for construction activities, which would result in a beneficial impact for local jobs and the regional economy. An increase in housing demand may result from the use of temporary workers during the construction phase. See **Chapter 8: Socio-Economics** for additional details.

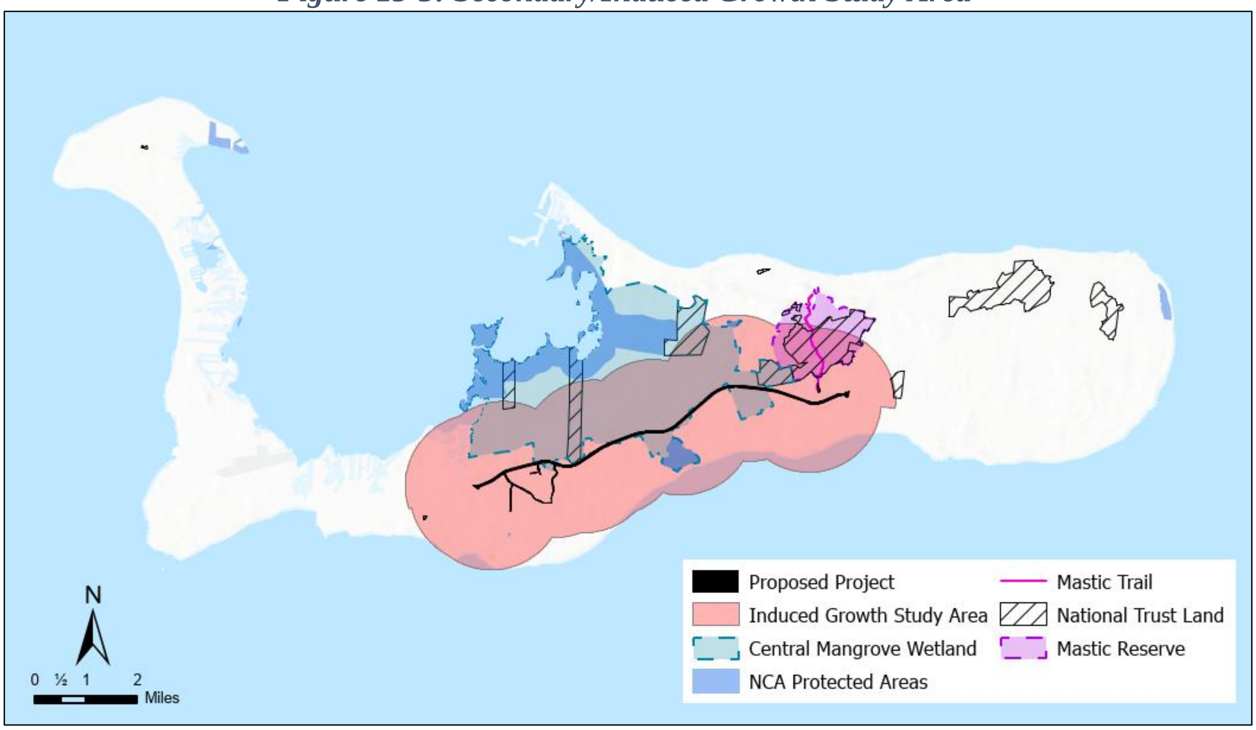
15.2.2.11 Construction Traffic Disruptions

Construction of the Proposed Project may result in temporary roadway closures or diversions while connecting the Proposed Project to the existing roadway network and building the Will T Connector. See **Chapter 8: Socio-Economics** for additional details.

15.3 Secondary/Induced Impacts

Secondary/induced impacts are reasonably foreseeable/ probable, happen at some future time other than direct impacts, are located within the bounds of systems affected by the project (Induced Growth Study Area), and are caused by other developments or induced by the project. The Study Area for secondary/induced impacts is a 1.5-mi (2.4 km) buffer around each proposed intersection location along the Proposed Project (**Figure 15-3**), as established within the ToR.

Figure 15-3: Secondary/Induced Growth Study Area



The results of an infrastructure project such as the EWA Extension continue for decades after the project is completed. To assess the long-term impacts of the proposed EWA Extension in the EIA, a future horizon year for analysis was chosen.

According to the UK Green Book, which is the Central Government Guidance on Appraisal and Evaluation:

> *"Costs and benefits should be calculated over the lifetime of an intervention. As a guideline, a time horizon of 10 years is a suitable working assumption for many interventions. In some cases, up to 60 years may be suitable, for example for buildings and infrastructure."*

After careful consideration a 50-year time horizon to the year 2074, was chosen to represent the life-cycle year for construction and it was the common year used for all evaluations. Therefore, the temporal scope for evaluation of potential future impacts discussed below is 2074.

15.3.1 Stakeholder Engagement

The outcomes of discussions held as part of Stakeholder engagement process were utilised to compile present and reasonably foreseeable actions as part of the EWA Extension EIA. Additional information regarding stakeholder engagement can be found in **Section 3.5.2: Stakeholder Engagement**, **Chapter 7: Transportation and Mobility,** and **Appendix C - Land Use Planning Charrette Summary Memorandum**.

For estimating future land use, a list and locations of anticipated developments through 2046 within Grand Cayman was provided by the NRA. The anticipated developments within the Induced Growth Study Area are depicted in **Figure 15-4** and **Figure 15-5**. Within the induced growth area, there are an estimated 73 ac (30 ha) of development, representing a population increase of about 3,050 persons (**Figure 15-4** and **15-5**).

Figure 15-4: Planned Development by Acres through 2046

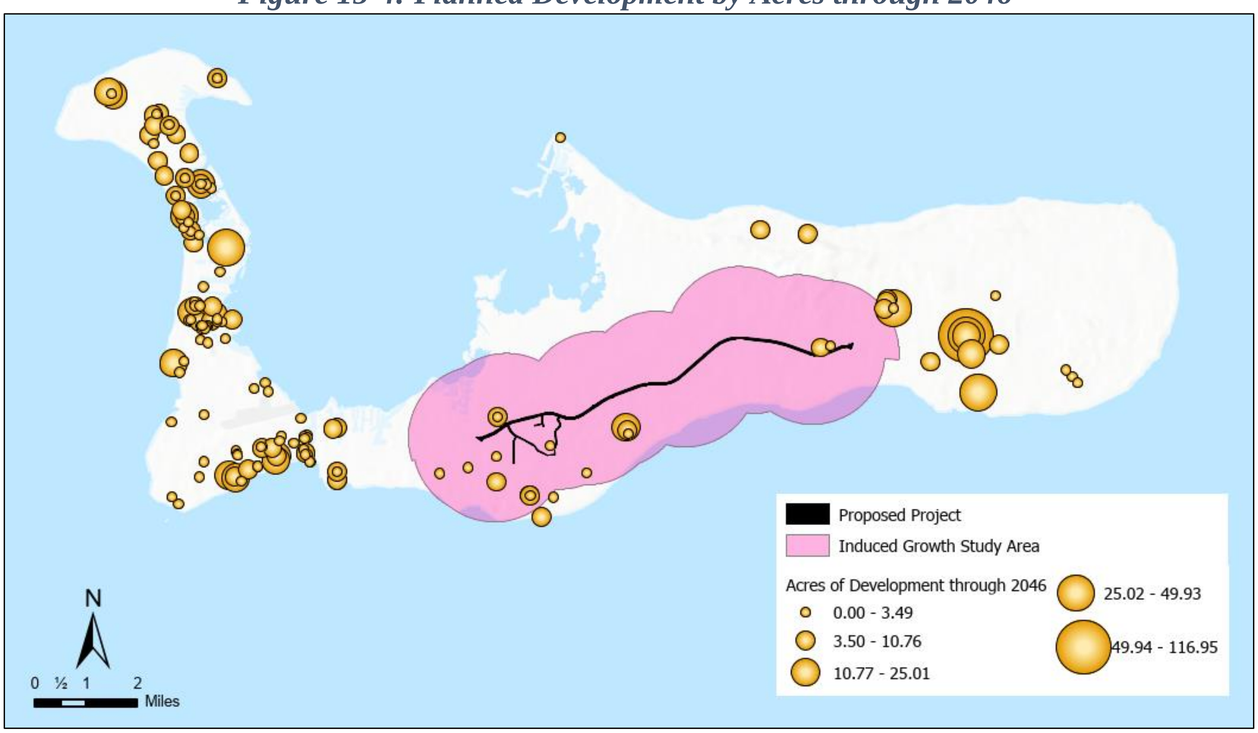
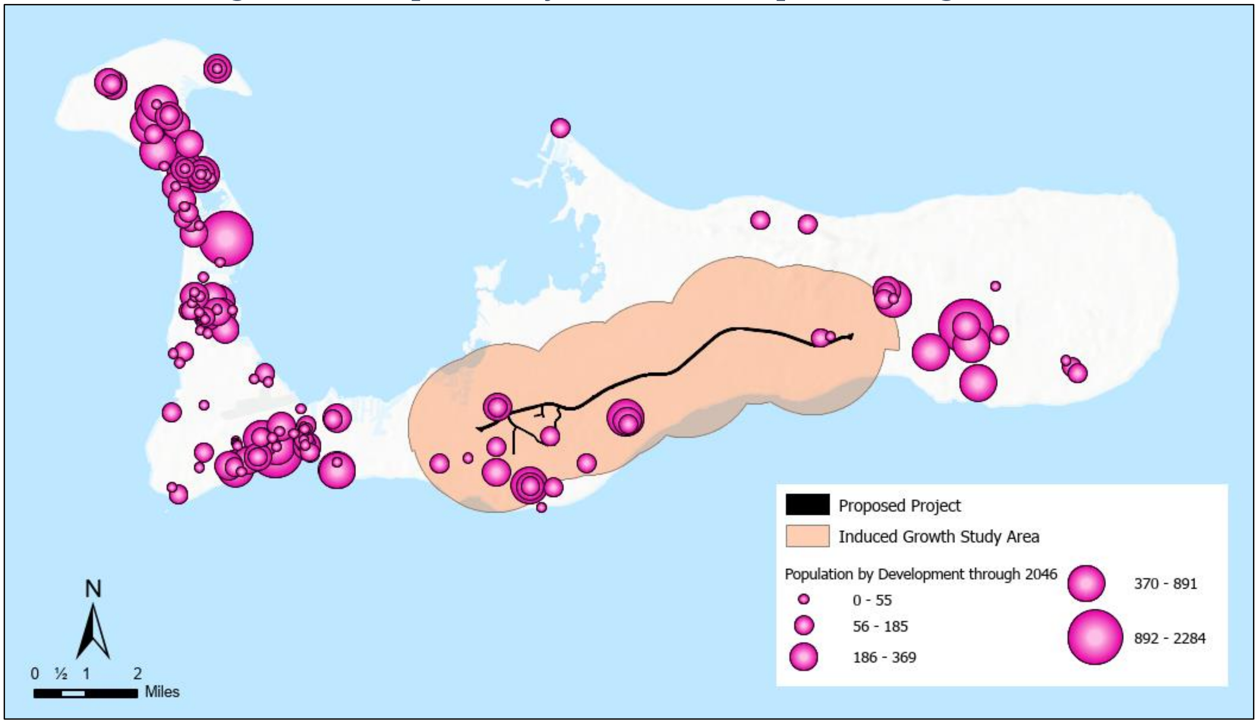


Figure 15-5: Population by Planned Development through 2046



To forecast the population on Grand Cayman in 2074, the project team gathered members of the EWA EIA Steering Committee and relevant government ministries and departments with the aim of agreeing on population growth scenarios that could then be used for EWA study and modelling purposes. On July 25, 2023, the EWA EIA project team conducted a Land Use Planning Charrette to achieve this aim (**Appendix C - Land Use Planning Charrette Summary Memorandum).**

Members of the EWA EIA Steering Committee and relevant government ministries and departments were in attendance, including government ministries and the following departments:

- NRA
- DoE
- EAB
- Department of Planning
- WAC
- Ministry of Planning, Agriculture, Housing, and Infrastructure
- Ministry of Sustainability & Climate Resiliency

The Land Use Charrette focused on determining three different land use scenarios that may occur on Grand Cayman in future year 2074 that included both geographically based and intensity-based components: where will the people be and how many people will be there. Main categories for consideration included: locations and number of population/density, employment, hotels, and cruise ships. The Charrette provided consensus on growth scenarios and geographical distribution to inform the traffic modelling efforts, which would dictate engineering requirements (number of lanes, intersection locations/configurations, etc.), and the CBA in terms of benefit (travel times, accessibility, benefited population, etc.). **Table 15-3** summarizes the three population growth scenarios from the Charrette. **Figures 15-6** through **15-8** show the three population growth scenarios in more detail.

Table 15-3: 2074 Population Projections from Land Use Charrette

	Baseline Population	Added Population	Projected 2074 Population
Low Growth Scenario	100,000 (70,000 current + 30,000 projected)	15,000	115,000
Medium Growth Scenario	100,000 (70,000 current + 30,000 projected)	35,000	135,000
High Growth Scenario	100,000 (70,000 current + 30,000 projected)	200,000	300,000

Figure 15-6: Low Population Growth Scenario

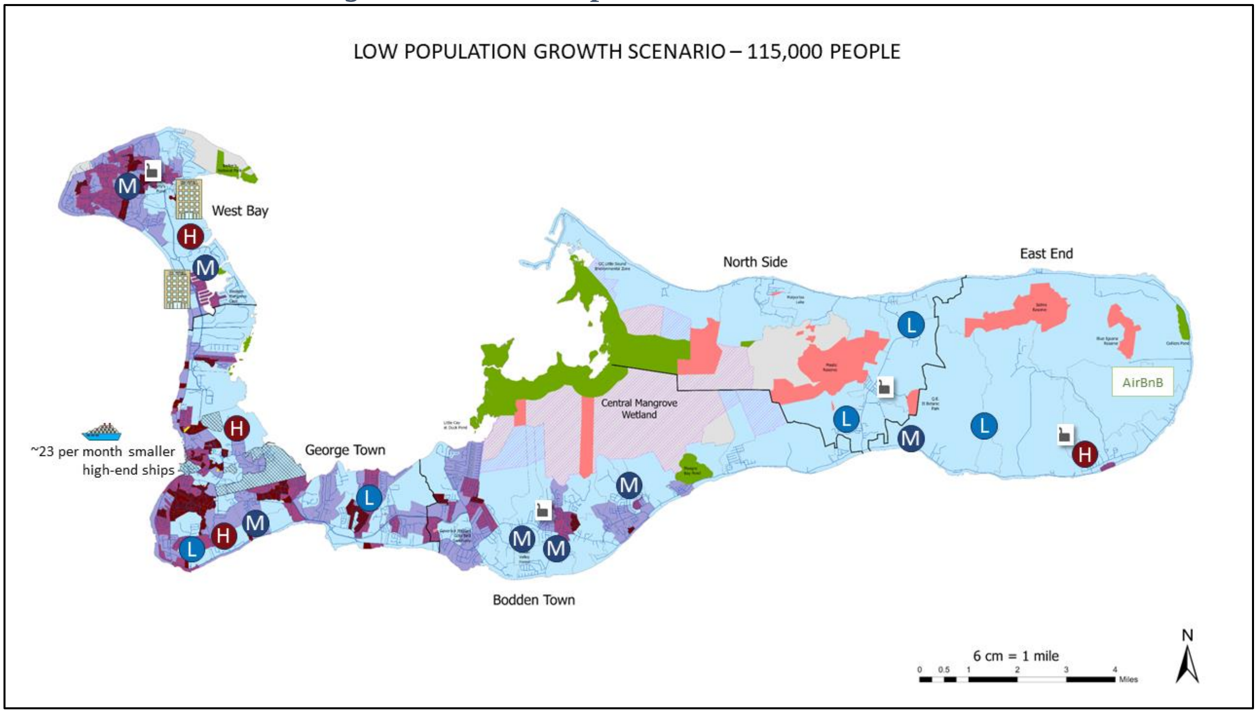


Figure 15-7: Medium Population Growth Scenario

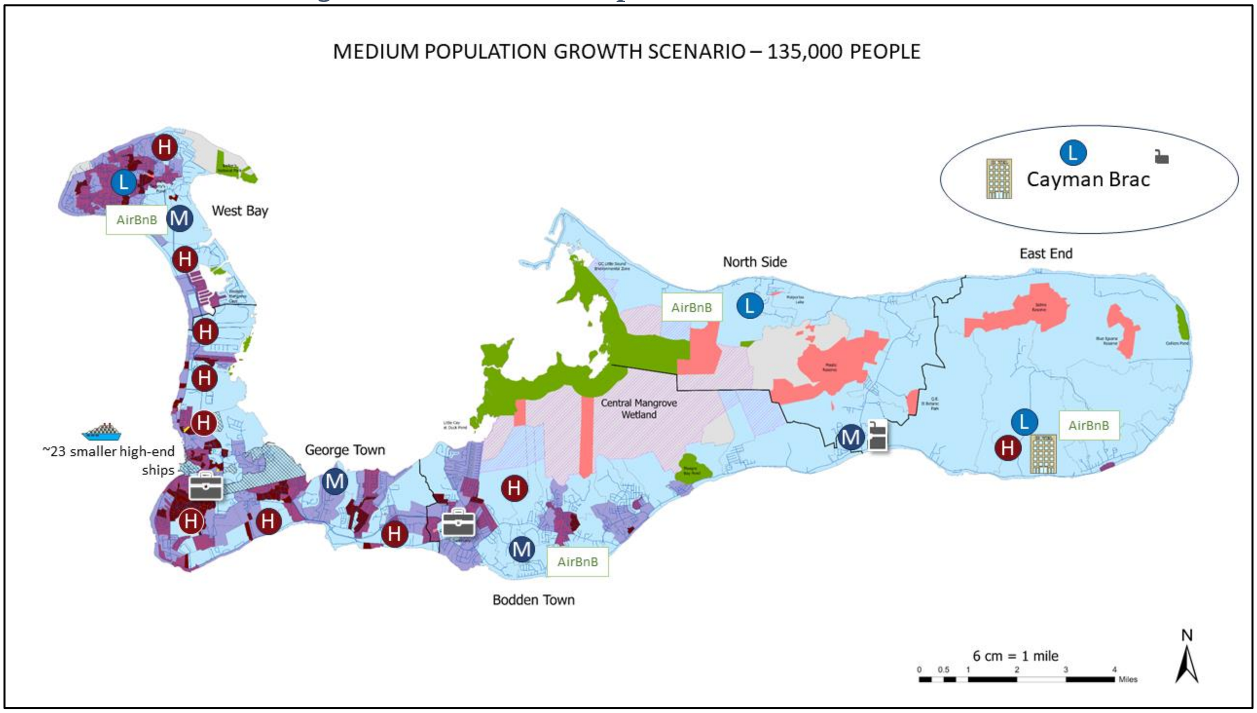
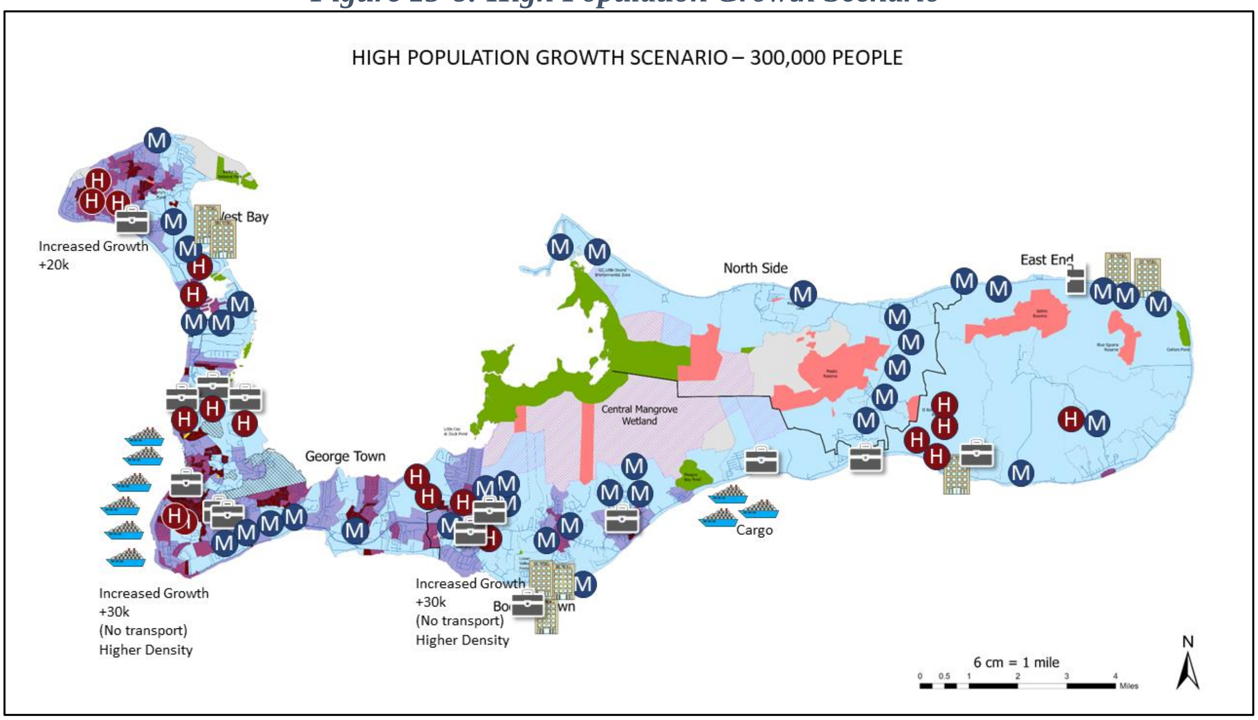


Figure 15-8: High Population Growth Scenario



15.3.2 Induced Demand

Induced traffic demand refers to the situation where roadway infrastructure projects intended to alleviate existing traffic congestion lead to a rise in overall vehicle trips. As an example, if a new road is built to alleviate existing congestion and accommodate additional vehicles, more people may choose to drive longer distances. This is due to improved accessibility to key destinations, such as access to jobs, that would be increasingly difficult to reach under the Future No-Build conditions since traffic congestion would continue to worsen.

When modelling the Proposed Project, the Grand Cayman Model (GCM) captures the induced traffic anticipated because of the EWA Extension by using a "variable demand" approach that reflects how travel conditions may change in response to the additional roadway capacity, rather than using a "fixed demand" approach that would assume the same travel patterns between the Future No-Build and the Proposed Project scenarios. According to WebTAG Unit M1-1 Principles of Modelling and Forecasting, the fixed demand approach is deemed "inadequate for transport schemes aimed at resolving congestion." Instead, variable demand models are more appropriate to best capture variations in demand as travel opportunities change. Therefore, the results discussed throughout this ES reflect the potential induced demand generated by the EWA Extension, and traffic volumes ultimately differ between the Future No-Build and Proposed Project. This includes incorporation of induced demand within socio-economic, noise and vibration, and GHG evaluations.

15.3.3 Induced Development

To fully ascertain induced development, a comprehensive understanding of the island's economics through an economic impact analysis is necessary. Therefore, to conduct a proper economic impact analysis of induced development resulting from the Proposed Project, the outcome would be to prove that the Proposed Project is anticipated to create additional economic activity at the national level that would not otherwise occur.

> *TAG Unit A2.2 highlights that induced development resulting from transport improvements can be a result of displacement or additionality. Displacement indicates that the geographic location or industry where investment occurs has changed due to the transport improvement, but economic impacts at a national level have not. Additionality indicates that the transport project has created net welfare changes at the national level. Proving additionality is necessary to attribute the economic impacts of induced development to the Proposed Project. The default position of all transport appraisals is 100% displacement unless context specific evidence can be provided that the investment leads to increased economic activity at the national level.* (Department of Transport, 2024)

Development is driven by market demand and supply. The market demand is driven by births, deaths, in-migration, out-migration and tourism as well as demand for services which increases as the population increases. These features are more dependent on economic policies such as immigration and labour policy than they are transportation supply for an island-based economy.

The ultimate location of developments is driven by elements such as access to jobs, access to amenities, cost of developing properties, and willingness of property owners to develop their property or sell their properties to developers. Development location operates as a function of the broader supply market which in this case is the overall real estate market for Grand Cayman. People can purchase an existing home for sale, purchase a lot to build a new home, or purchase a home from a developer anywhere on the island. The location that they choose will be based on elements such as cost, travel time to work or services, access to amenities such as the beach or shopping, and criminality level. The Proposed Project will influence some of these supply factors but not influence the overall demand.

Induced development can be considered both a benefit and disbenefit depending on the parameter being evaluated and the context of the situation. For example, there can be a benefit from a socio-economic perspective since there could be an increased value of the property to be developed along with any potential growth in jobs and improved quality of life. From this perspective induced demand is often used to help justify new transportation projects. From an environmental impact perspective, induced development may be associated with an increase in environmental impacts which can be considered a disbenefit.

Detailed information on the current and past real estate market; current, past, and future immigration policies; current, past, and future labour policies; and current and past location-specific development and occupancy patterns are the types of information typically required to develop and calibrate a detailed econometric model for use in assessing both supply and demand. Due to the absence of an available model of this type along with the levels of detailed information needed to produce a new model, a different approach was developed to analyse induced development.

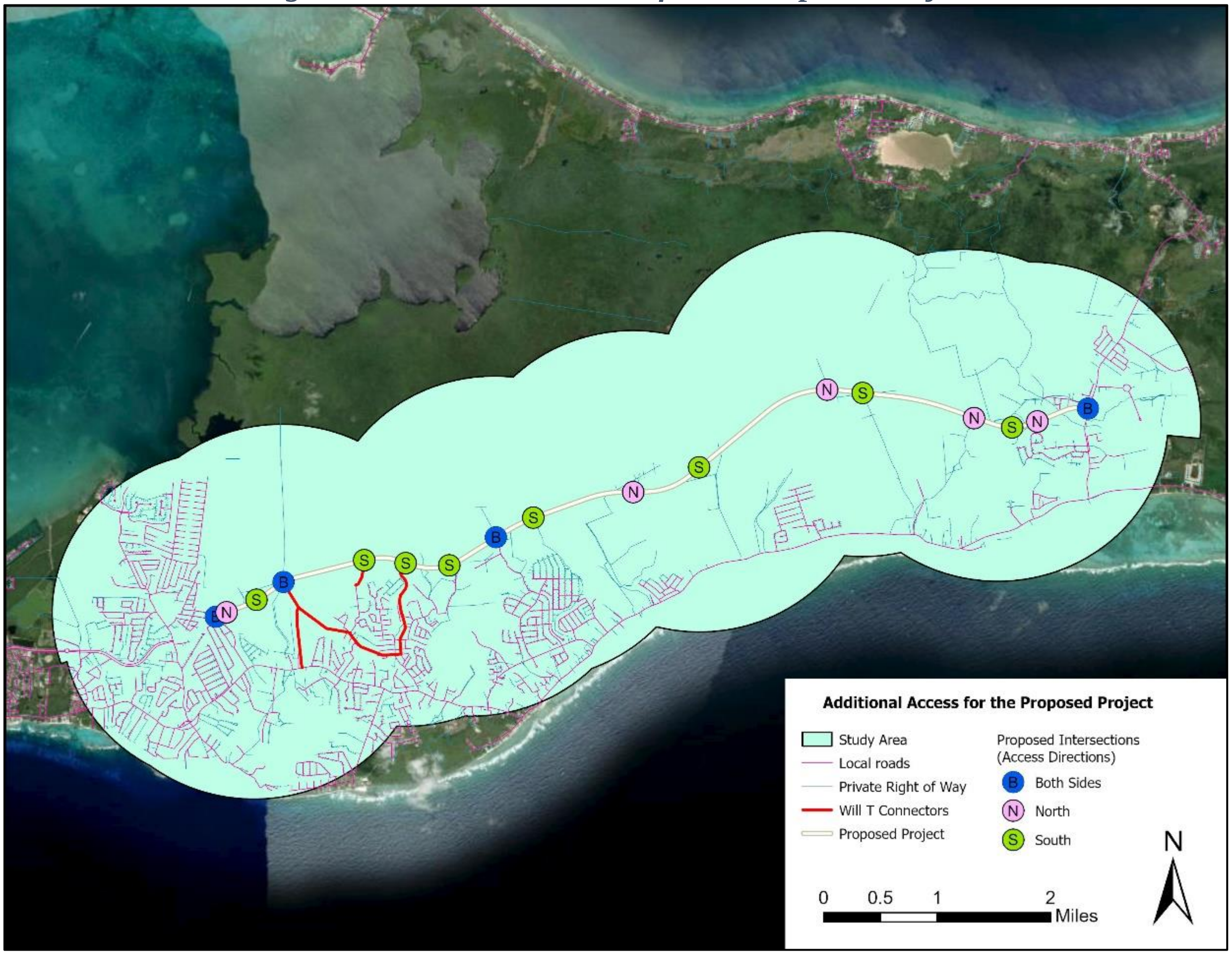
A project specific model was prepared to analyse the Proposed Project from a development propensity perspective. The results obtained from this model do not imply that the Proposed Project would result in induced development since it does not assess demand-side factors, but rather that the Proposed Project improves the transportation-related aspects of potential development location choice. These impacts have not been specifically accounted for as either benefits or disbenefits of the Proposed Project, but rather as elements that need to be accounted for as Grand Cayman proceeds with development planning and establishing development regulations. In addition, there are mitigation techniques available that could strengthen development regulations to discourage or prohibit development in environmentally sensitive areas such as the CMW, if that is a desired outcome.

15.3.4 Land Use Development Propensity Forecasting

A project specific development propensity prediction tool was prepared to generate estimates of how the change in accessibility due to the Proposed Project may impact the tendency for future land development at a parcel-level resolution for the study area. This future land development propensity can be useful for land use planners and decision makers to understand the potential for future land use changes that may occur with or without the Proposed Project. The full study of future land development propensity forecasting can be found in **Appendix L – Land Use Development Propensity Forecasting**. A summary of the study and results are included within this section.

The study area for the future land use forecasting was defined as a 1.5 mi (2.4 km) buffer area surrounding the intersection locations along the Proposed Project (**Figure 15-9**). This is based on the study area for induced growth as defined within the ToR.

Figure 15-9 Additional Access for the Proposed Project



The contributing factors for development propensity that were considered in the analysis included: land use zoning, planned development indicators, protected/NT/government indicators, area score[7], and access to roadways. These factors were categorized into three categories:

- Planned development
- Area type
- Access to transportation facilities

Using the prediction tool described in **Appendix L – Land Use Development Propensity Forecasting**, future land development propensity levels were identified for the Future No-Build as well as for the Proposed Project. Parcel-level prediction results under both these conditions are presented in **Figures 15-10** and **15-11**. It was estimated that the parcels close to the Will T Connector or the planned intersections along the Proposed Project were predicted to have higher propensity for development. The study results indicate that 60 parcels totalling 2,442 ac (988 ha) adjacent to and near the Proposed Project were estimated to have higher propensity classification due to the Proposed Project (**Table 15-4**). Most of the High and Very High development propensity

[7] "area score" incorporates land use zones' shares within a grid system. Details regarding "area score" generation are included within **Appendix L – Land Use Development Propensity Forecasting**

parcels are south of the Proposed Project or near the Western or Eastern limits of the Proposed Project.

The estimated total parcel areas for the five defined propensity levels are summarized in **Table 15-4**. From the comparison, the Proposed Project increases the overall acreage of Low and Medium Development Propensity by 110.4% and 132.2%, respectively. The increase in acreage for High and Very High Development Propensity is significantly less at 3.8% and 3.7%, respectively.

Table 15-4: Estimated Development Propensity Levels

Propensity Level	Area in Acres		Percentage Difference in Acreage
	Future No-Build	Proposed Project	
Very Low	6,262.2	3,986.1	-36.3%
Low	1,015.8	2,137.3	110.4%
Medium	807.2	1,874.4	132.2%
High	1,009.0	1,047.5	3.8%
Very High	1,331.5	1,380.4	3.7%

Throughout the study area, land use zones were classified based on development propensity. Among these land use zones, only agricultural/residential and low-density residential zones were found to experience different propensity levels due to the Proposed Project. Specifically, agricultural/residential and low-density residential zones may experience induced development while other zones may not. This is very much intuitive because density of these two land use types is prominent close to the proposed project. Refer to **Appendix L – Land Use Development Propensity Forecasting: Section 5.2 with Tables 4 through 11** for the identified land use zones and corresponding propensities for each zoning category. It is worth noting that the study area contains capacity for a substantial amount of potential development. For example, assuming the following simple factors for capacity of single-family households (HH) within residential zoning categories: Agricultural/Residential – 2 HH/Ac; Low Density Residential – 4 HH/Ac; and Medium Density Residential – 6 HH/Ac, then the Future No-Build includes the capacity for 8,316 new households in parcels with High and Very High Propensity for development. The Proposed Project includes the capacity for 8,600 new households in parcels with High and Very High Development, most of which are in the area south of the Proposed Project or near the Eastern or Western project limits. However, it is important to note that the results are not absolute and are based on a mathematical formulation. Areas noted as very high propensity may develop slowly, and as very low propensity may develop quickly based on factors not included in the model.

Propensity levels were also evaluated and compared within the CMW[8]. From the following table (**Table 15-5**), it is noteworthy that land development propensity in the CMW is significantly lower overall when compared to the remaining study area. The Proposed Project is expected to increase

[8] Based on Central Mangrove Wetland (*.shp shapefile) provided by the Cayman Islands Department of Environment July 2023

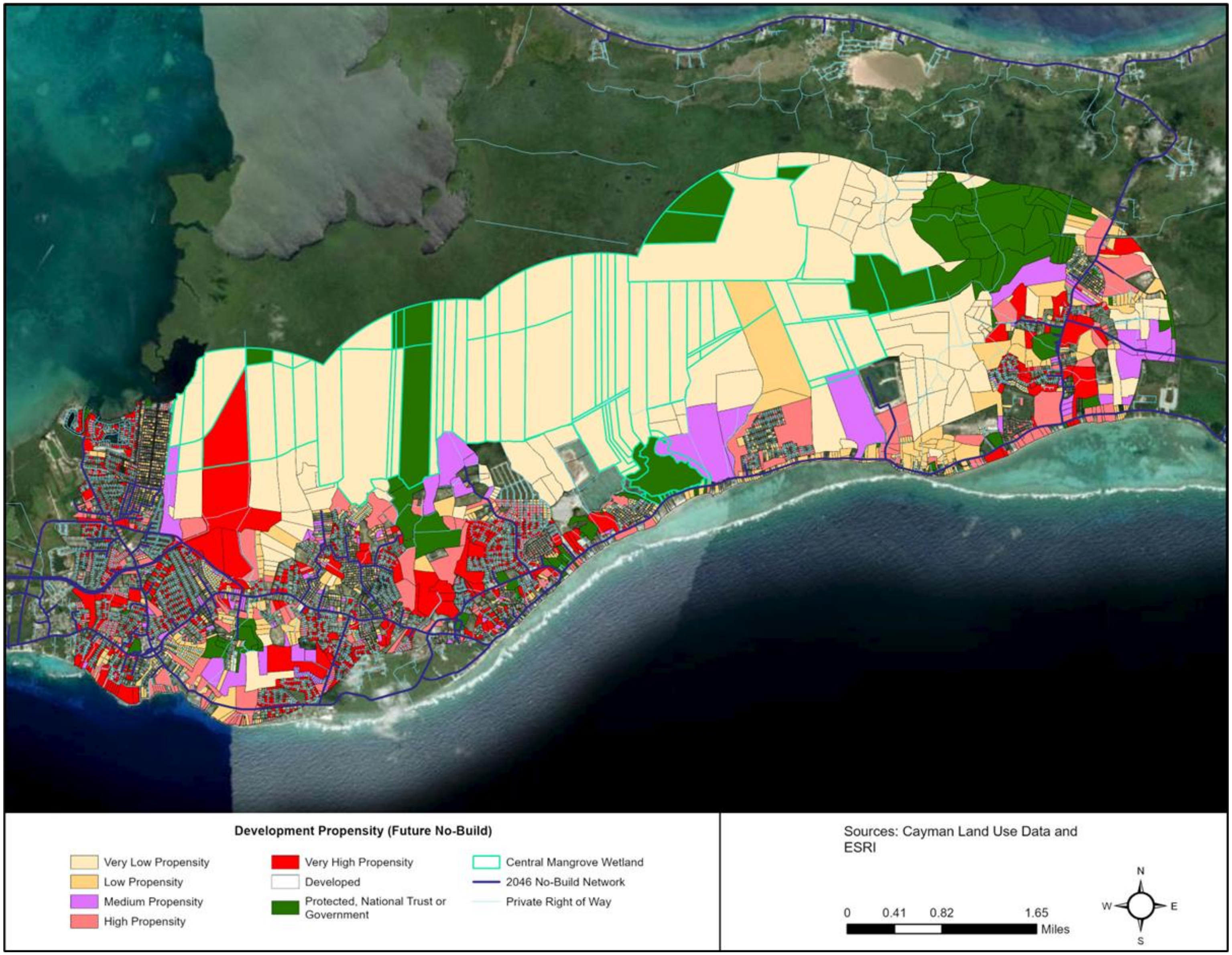
the propensity for development for the low, medium and high levels. It is projected that there would be an increase of 950 ac in the low propensity level and an increase of 678.3 ac in the medium propensity level when compared to the No-Build. In total, 1,628.4 ac of CMW may shift from very low to the next three higher development propensity levels (low, medium and high) because of the Proposed Project.

Table 15-5: Propensity Comparison for Central Mangrove Wetland

Propensity Level	Area in Acres		Percentage Difference in Acreage
	No-Build	Proposed Project	
Very Low	4,031.6	2,403.2	-40.4%
Low	73.8	1,023.8	1,288.0%
Medium	47.2	725.5	1,437.9%
High	1.3	1.4	10.0%
Very High	129.1	129.1	0.0%

Overall, the Proposed Project improves transportation access, and therefore, increases the propensity for development. Based on the analysis results, the parcels south of the Proposed Project corridor are generally expected to have a higher likelihood of development when compared to those north of the Proposed Project corridor. This is mainly because of having better transportation access (both intersection access and Will T Connector), higher area scores, and lower density of protected land. As previously noted, this evaluation has several limitations mainly due to data availability constraints which are discussed in detail in **Appendix L – Land Use Development Propensity Forecasting**.

Figure 15-10 Future No-Build Development Propensity



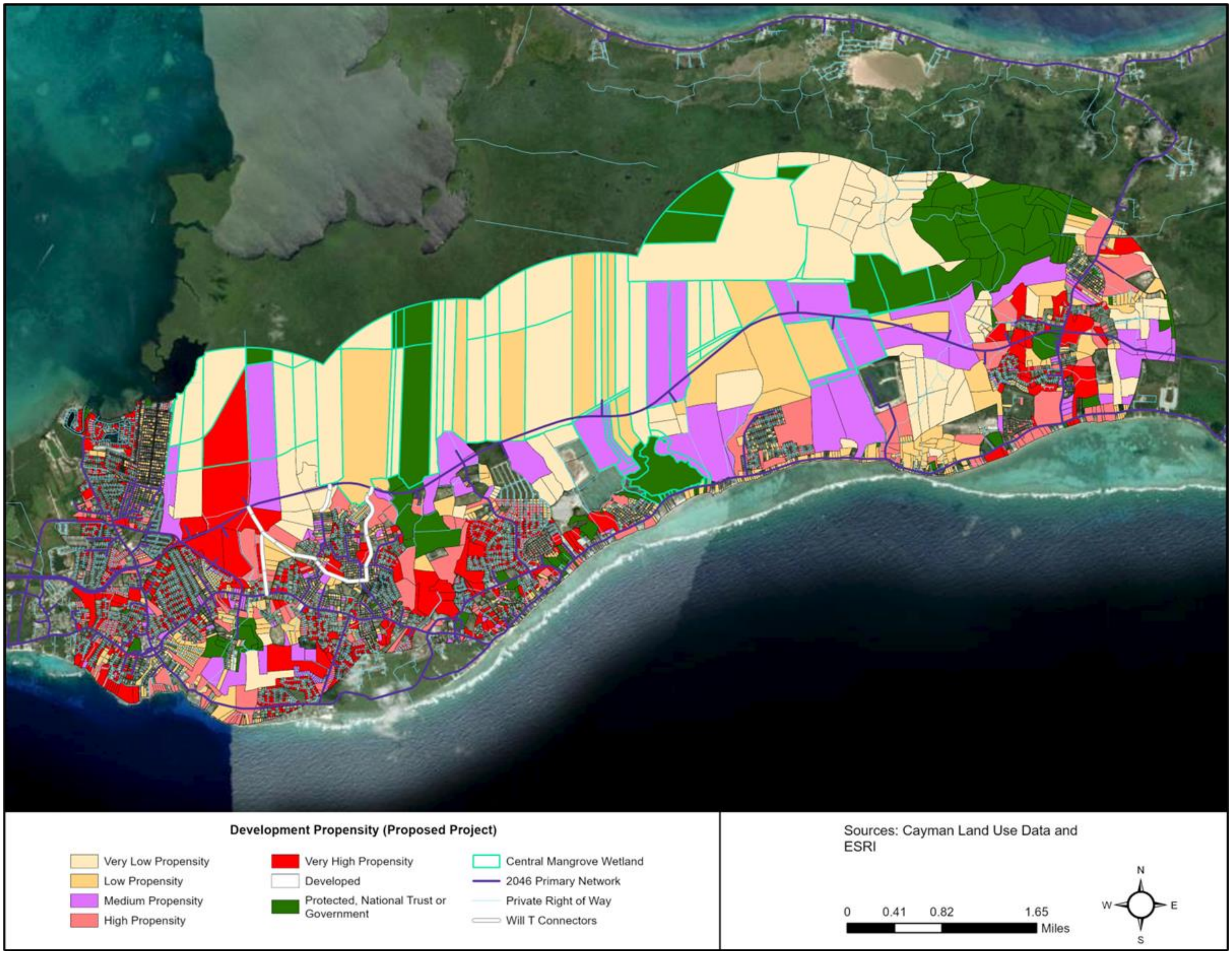


Figure 15-11 Proposed Project Development Propensity

15.4 Cumulative Impacts

The Cayman Islands' 2016 EIA Directive (NCC, 2016) defines cumulative impacts as:

> *"Impacts that result from incremental changes caused by other past, present or reasonably foreseeable actions together with the project."*

According to the European Commission's *Environmental Impact Assessment of Projects* guidance, which is referenced within the UK *Infrastructure Planning (Environmental Impact Assessment) Regulations 2017*, cumulative impacts are defined as:

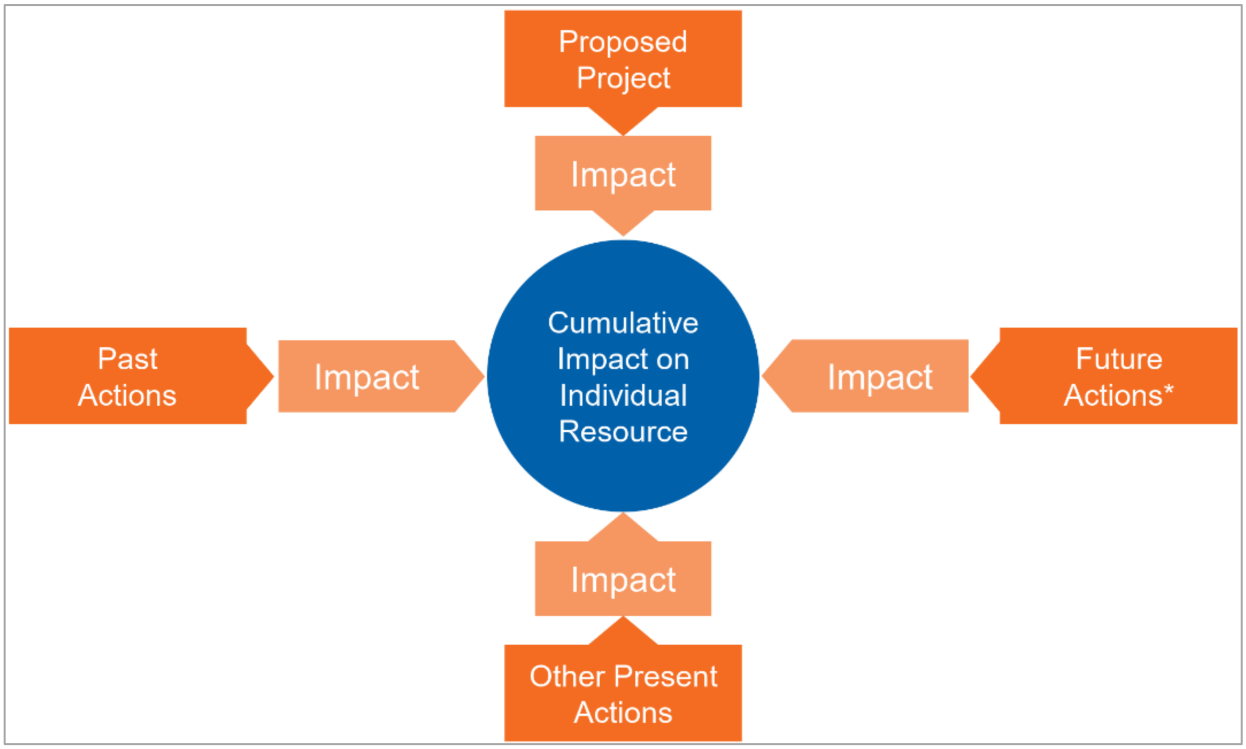
> *"Changes to the environment that are caused by an action in combination with other actions. They can arise from:*
>
> - *the interaction between all of the different Projects in the same area;*
> - *the interaction between the various impacts within a single Project."*

The UK's *Infrastructure Planning (Environmental Impact Assessment) Regulations 2017* includes the following as part of the description of significant effects on the environment:

> *"The cumulation of effects with other existing and, or approved projects, taking into account any existing environmental problems relating to areas of particular environmental importance likely to be affected or the use of natural resources"*

Cumulative impacts include the total of all impacts, direct and indirect, experienced by a particular resource that have occurred, are occurring, and would likely occur as a result of any action or influence, including impacts of a federal activity (EPA, 1999), as illustrated in **Figure 15-12**.

Figure 15-12: Cumulative Impacts Diagram



Source: FHWA, 2019

15.4.1 Past Actions

The social, economic, and cultural landscape of the islands changed significantly in the second half of the 20th century. The 1950s saw the establishment of two major industries for the Cayman Islands: finance and tourism. In 1953, the first airfield, hospital, and commercial bank opened on Grand Cayman. Hotels started to open in early 1950 and in late 1950 a commercial dive centre opened, all of which encouraged tourism. In 1966, legislation was passed to encourage the banking industry (Boxall, 2023; Cayman Islands Government, n.d.). In the decades that followed, international banks, accounting firms, and law firms found the Cayman Islands an attractive place to do business (Boxall, 2024). Today the Cayman Islands are a major centre for international finance.

The 1960s also mark the time when the islands started experiencing significant population growth (Boxall, 2024). From a population of 8,511 in 1960, the population has experienced rapid growth through the decades, reaching 55,036 in 2010 and 81,546 in 2022 (see **Chapter 8: Socio-Economics** for more information). Development grew with the expanding population to add urbanization, businesses, infrastructure, transportation, and many other social amenities (Hughes, 2017).

A significant mosquito problem led to the Mosquito Research and Control Unit (MRCU) being established in 1965, and the Mosquito (Research and Control) Law first being passed in 1966. Between 1967 and 1983, dyke and canal building occurred in the swamps of Grand Cayman, producing a network that allowed the water levels in the swamps to be manipulated to interrupt mosquito breeding cycles (the "Hatch and Strand" program). In 1996, additional swamp excavation (creating 'canalitos') occurred to increase the flow of water with the tide and rainfall (MRCU, n.d.-a). The Hatch and Strand program continues to be used to flood and drain large sections of swamp to prevent mosquito populations from growing. This practice intentionally alters the natural hydrology of the swamps during mosquito breeding season, and the existing canal system also acts to passively control tidal variation and drain heavy rainfall (MRCU, n.d.-b). This control of mosquito populations is a necessary component in making the environment of the Cayman Islands pleasant for residents and tourists (Hughes, 2017).

As a result of the development that occurred during the second half of the 20th century, the natural spaces of the island experienced deforestation, wetland loss, and invasive species introduction (including the green iguana, the agouti, and various invasive flora). Another alteration of the natural environment has been natural disasters, specifically hurricanes. Hurricane Gilbert passed just southeast of Grand Cayman in 1988 (Hughes, 2017). Hurricane Ivan, in 2004, was an extremely destructive force that caused long-lasting damage to the built and natural environments (for more information please see **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**, and **Chapter 13: Terrestrial Ecology**).

Environmental protection in the Cayman Islands focuses on conserving Grand Cayman's natural resources through land-protection efforts like setting aside portions of the CMW under the NCA or the NT purchasing parcels of CMW and Mastic Reserve land. Conservation of important species including the endangered and endemic blue iguana occurs at the Queen Elizabeth II Royal Botanic Park. Some of these conservation spaces, like the botanic park and the Mastic Trail, are noted tourist destinations. There are also other important areas of work such as captive breeding and release (specifically in relation to the Blue Iguanas), removal and management of invasive species as well as the management of "take" for marine and terrestrial species through specific regulations that are also utilised.

15.4.2 Present and Reasonably Foreseeable Actions Future Actions

At the time of this analysis, comprehensive planning documents for the Cayman Islands are actively undergoing revision to update the 1997 Development Plan. In addition, various types of stakeholder engagement, as described in **Section 15.3.1: Stakeholder Engagement**, was utilised in order to compile present and reasonably foreseeable actions as part of the EWA Extension EIA.

The existing zoning within the Secondary/Induced Study Area is shown in **Figure 15-13** and summarized in **Table 15-6**. Currently, the primary zoning within the Secondary/Induced Study Area is Agricultura/Residential followed by Low Density Residential.

Figure 15-13: Development Zoning with the Induced Growth Study Area

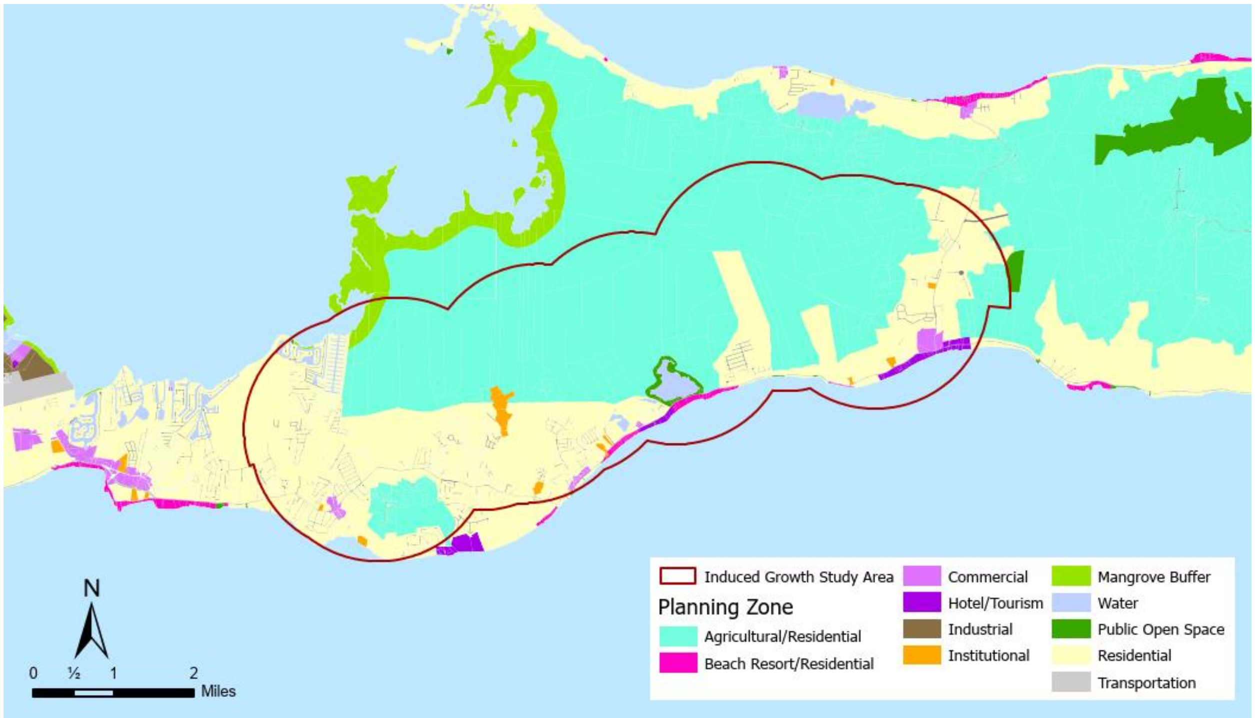


Table 15-6: Development Zoning Acreage within Induced Growth Study Area

Development Zoning	Acres	Hectares
Agricultural/Residential	8,717	3,528
Approved Roadway Corridor	4	2
Beach Resort/Residential	55	22
Hotel/Tourism	90	36
Institutional	103	42
Low Density Residential	5,480	2,218
Mangrove Buffer	82	33
Medium Density Residential	305	123
Neighbourhood Commercial	97	39
Ponds	115	47
Private Canals	58	23
Private Roads	181	73
Public Open Space	78	32

Based on the evaluation within **Section 15.3.1: Stakeholder Engagement**, the known planned developments through 2046 within the Secondary/Induced Study Area are summarized in **Table 15-7**. Most of these developments are subdivisions planned to contain single-family units; and one planned development is mixed-use, with both single-family units and a commercial space.

Table 15-7: 2046 Planned Developments Within the Induced Study Area

Development Type	Number of Developments	Area	Estimated Population Capacity
Single-Family Residential	14	63.2 ac (25.6 ha)	2,779
Residential Condominiums	3	8.8 ac (3.6 ha)	272
Commercial	2	98,000 ft^2 (9,105 m^2)	N/A

Based on the evaluation within **Section 15.3.4: Land Use Development Propensity Forecasting**, the Proposed Project improves transportation access, and therefore, increases the propensity for development through horizon year 2074. Based on the analysis results, the parcels south of the Proposed Project corridor are generally expected to have a higher likelihood of development when compared to those north of the Proposed Project corridor (**Figure 15-11)**. This is mainly due to having better transportation access (both intersection access and Will T Connector), higher area scores, and lower density of protected land.

15.4.3 Natural Environment Cumulative Impacts

As described in **Section 15.4.1: Past Actions**, the natural environment has been impacted by past anthropogenic stressors and impacts, including population growth, mosquito dykes, quarries, and development. The existing environmental regulations for the Cayman Islands are relatively new (the NCA of 2013 and the EIA Directive of 2016), and prior impacts to the environment were not quantified or assessed to a legal standard or framework and may not have been documented. Therefore, the prior environmental damage from development changes are unreported and collectively unknown.

As described in the previous Chapters of this ES, it is estimated that the Proposed Project could result in various impacts to natural resources, such as habitat loss and fragmentation, changes to hydrological flow patterns and/or water quality, loss of peat, impacts to species and their habitats, and changes to the recharge and water within the freshwater lenses. These potential impacts and conceptual mitigation strategies for the Proposed Project are being evaluated as part of this EIA, with a goal of No Net Loss in biodiversity as a result of the Proposed Project.

Future land use changes could also directly affect the study area through 2074. These potential land use changes also include the secondary/induced impacts discussed in **Section 15.3: Secondary/Induced Impacts.** In addition to land use changes, climate changes could affect the study area through 2074. The low-lying topography of Grand Cayman is vulnerable to winds and flooding caused by hurricanes and tropical storms. Climate change could affect the amount, intensity, and duration of rainfall, temperature, and evapotranspiration, as well as the occurrence of extreme weather (e.g., hurricanes) and sea level rise. See **Chapter 12: Hydrology and Drainage, Including Climate Resiliency**.

The potential for cumulative impacts on natural resources through 2074 from land use and climate change has been identified, though these impacts are not certain. The environmental management of past, current, and future projects plays a major role in preserving or damaging the natural resources within and adjacent to these projects. Present and future developments would be subject to the NCA and the EIA Directive and any future environmental planning, zoning, or regulation. The significance of the future cumulative impacts to the natural environment from all developments would also be dependent upon avoidance, minimisation, mitigation, and resiliency strategies undertaken in future.

15.4.4 Social Environment Cumulative Impacts

Many factors have contributed to the changing social environment in the Cayman Islands, especially in the second half of the 20th century. As discussed in **Section 15.4.1: Past Actions**, numerous socioeconomic amenities became available at the beginning of a period of significant population growth, accounting for a population of over 80,000 people by 2022. Development occurred to accommodate this population growth, urbanizing the western side of Grand Cayman.

In 1971, the *Development and Planning Law* was passed. This law has been updated and revised many times, and is currently the *Development and Planning Act (2021 Revision)*. The 1971 law established the Central Planning Authority and made that authority responsible for preparing a development planning document. The purpose of the plan was to indicate how land is used. The plan was updated in the 1990s and is currently undergoing a revision as of 2024 (the 2024 Planning Statement). These planning documents have set down zoning, including indicating areas like residential development, commercial development, tourism, and environmental zones, which guided past development. The upcoming plan revision are expected to continue to guide physical development and land use while adapting to a growing population. The Proposed Project is consistent with the transportation goals described in the February 2023 National Planning Framework, which represents the overarching vision, goals, and objectives of the 2024 Planning Statement.

The *Cayman Islands National Energy Policy 2024-2045* includes socioeconomic and environmental sustainability within its four goals. The National Energy Policy recognizes the connection between sustainability goals and the socioeconomic wellbeing of Caymanians. Transportation strategies are outlined within the policy that support the social environment. The Proposed Project is consistent with several of these goals, including:

- 3.4.3 Transportation Sector Strategy: Encourage bicycles and e-bikes as an alternative mode of transportation and work with the Ministries responsible for transportation and land use planning to develop strategies to increase bicycle safety
- 3.4.4 Transportation Sector Strategy: Optimize traffic efficiency and address current bottlenecks

The Cayman Islands are continuing to experience population growth and are faced with evaluating the development and infrastructure needed to accommodate the additional population. The Proposed Project is consistent with long-range planning and energy goals focused on reducing congestion and providing additional, non-vehicular modes of transport to the general population. While past cumulative impacts have contributed to issues including increased traffic and a lack of east-west connectivity, overall, the social environment has continued to evolve. Future planning goals indicate that a growth trend will continue through 2074, with the Proposed Project contributing to aid in accommodating this growth.

15.4.5 Summary of Cumulative Impacts

Past actions have led to the existing state of the natural and social environment within the study area. Since the second half of the 20th century the social, economic, and cultural landscape of the islands changed significantly. These past changes have been both beneficial and adverse to the social environment and primarily adverse to the natural environment. The degree of adverse impact to the natural environment from past actions was partly due to the lack of strong protective regulations.

The present and reasonably foreseeable actions within the study area are anticipated to include land use changes due to development. Based on the land use development propensity forecasting completed (**Section 15.3.4: Land Use Development Propensity Forecasting**), the Proposed Project improves transportation access, and therefore, increases the propensity for development. Based on the analysis results, the parcels south of the Proposed Project corridor are generally expected to have a higher likelihood of development when compared to those north of the Proposed Project corridor. This is mainly because of having better transportation access (both intersection access and Will T Connector), higher area scores, and lower density of protected land. The improved accessibility resulting from the Proposed Project, and land use changes which would increase availability in housing and create jobs would be expected to result in an overall beneficial cumulative effect to the social environment.

The natural environment within the study area is susceptible to future land use impacts from present and reasonably foreseeable actions. Present and future developments would be subject to the NCA and the EIA Directive and any future environmental planning, zoning, or regulation. The significance of the future cumulative impacts to the natural environment would also be dependent upon avoidance, minimisation, and mitigation strategies undertaken in future.

The significance of future cumulative impacts (both natural and social) is directly dependent on future decision-making (regulation, planning, environmental law) and could vary widely from what is described throughout this Chapter.

16 Cost-Benefit Analysis

A Cost-Benefit Analysis (CBA) was performed by monetising the anticipated costs and quantitative benefits of the EWA Extension under varying 2074 population growth/land use scenarios. This analysis was carried out for two primary conceptual design options, with each option representing a different approach to balancing initial construction costs, storm resiliency, and long-term maintenance expenditures. These conceptual design options are referred to as “Excellent Fit” and “Acceptable Fit” throughout this chapter; and the criteria for each is described in **Section 6.3: Value Engineering and Future Cost Reduction Considerations**.

This CBA chapter of the ES focuses on describing the methodology used to quantify and monetise benefits, discount future cost and benefit values to constant 2024 United States dollars (USD) and 2024 Cayman Island dollars (CI$)[9]. USD has been converted from CI$ at a rate of $1.00 CI = $1.19 US; $0.84 CI = $1.00 US. The CBA compares the Net Present Value (NPV) and benefit/cost ratio (BCR) for the three 2074 scenarios and two primary conceptual design options.

Note that not all benefits are monetised as part of the CBA. Additional qualitative and quantitative evaluation of benefits can be found within Chapters 6 to 15 of this Environmental Statement.

This chapter assesses the effects of the Proposed Project described in **Chapter 6: Proposed Project – Engineering Features** considering the above-mentioned conceptual design options. The Future No-Build conditions are consistent with **Chapter 7: Transportation and Mobility** and are used as a basis of comparison with the Proposed Project.

Monetised values for each cost and benefit category—undiscounted, discounted and broken out by year of analysis—can be found in the supplementary materials to this report **(Appendix M – Cost-Benefit Analysis).**

16.1 Assessment Methodology and Evaluation

A typical CBA is a process that compares future costs with future benefits in monetary terms. This CBA uses methodology and parameter values recommended in the UK Transport Appraisal Guidance (WebTAG), dated October 2024, and in the U.S. Department of Transportation (USDOT) Benefit-Cost Analysis Guidance for Discretionary Grant Programs, dated December 2023. The analysis in this report involves three steps: (1) itemize relevant costs and benefits in constant 2024 dollars, (2) apply a discount rate that represents the time value of money to ensure an equitable comparison between future benefits and costs, and (3) sum and compare the total discounted benefits and costs occurring over the project life cycle to identify their overall BCR and difference. This discounting process is important because costs are largely incurred in early years, and most benefits occur further out in time. This chapter presents the costs and benefit streams in both undiscounted and discounted terms, though only the latter can be used for cost-benefit comparison. The analysis period for costs and benefits (excluding the solar array) begins in 2024 with Right of Way (ROW) acquisition and ends in 2074 in the final year covered by the Grand Cayman Travel Demand Model (GCM).

[9] A constant 2024 dollar refers to the costs adjusted from different years for inflation for comparison in 2024 dollars.

The solar array analysis of benefits extends to 2075 to account for the full useful life of the solar array infrastructure. The methodology and results of the solar array CBA are included within **Appendix E - Shortlist [Alternatives] Evaluation: Attachment J – Cost-Benefit Analysis – Assessment of Alternatives**.

There are a number of benefits which were qualitatively assessed and discussed in the ES chapters (e.g., Critical Success Factors (CSFs) discussed in **Chapter 7: Transportation and Mobility**) but not monetised as part of the evaluation due to available data, its level of detail, and its applicability at the time of assessment, such as safety benefits, public transportation benefits, transportation system resiliency, and pedestrian/bicycle amenities. Additionally, though accessibility benefits are not monetised in this CBA, the Proposed Project creates improved access to more desirable work, education, shopping, and other welfare benefits that improve users' quality of life.

16.1.1 Discount Rate

This analysis presents results using UK Transport Appraisal Guidance (WebTAG) standard discount rates of 3.5% for years 1-30 and 3% for years 31-52 (WebTAG Data Book Unit A1.1.1). For health-related noise and non-carbon benefits, results are presented with WebTAG standard discount rate of 1.5% for years 1-30 and 1.29% for years 31-52. The usage of these discount rates was agreed upon by the NRA and the EAB.

This evaluation also includes an additional sensitivity analysis with 2% and 5% discount rates included in the supplementary materials to this report (**Appendix M – Cost-Benefit Analysis**) and **Table 16-18**.

16.1.2 Population Growth / Land Use Scenarios

To account for uncertainty in future development patterns on Grand Cayman, this CBA evaluates the anticipated costs and benefits of the Proposed Project under three 2074 scenarios of varying land use development and population growth (low, medium, and high). These three projections were developed based on input from various stakeholders in Grand Cayman, with detailed assumptions included in **Appendix C - Land Use Planning Charrette Summary Memorandum** and in **Chapter 7: Transportation and Mobility**.

Under the High Growth scenario, the 2074 population is projected to more than double compared to the Low and Medium Growth scenarios. Without additional transportation investments to accommodate this growth by 2074, the High Growth scenario would result in highly congested No-Build conditions with very low travel speeds across Grand Cayman. Roadways are projected to become so overburdened that many people's travel choices would become confined to very short trips, usually without driving. The Proposed Project is anticipated to offer localized benefits, making farther trips more feasible. However, overall network-wide transportation impacts are difficult to assess under these conditions due to such severe congestion. Given the level of deterioration in the transportation system's performance in the High Growth scenario, it seems unlikely that this level of population and land use change would occur without significant infrastructure improvement through projects such as the EWA. To support this level of population growth, broader infrastructure investments (e.g., utilities, transportation, public services, schools, etc.) would be essential. Therefore, this CBA chapter only evaluates the anticipated costs and benefits under the Low and Medium Growth scenarios.

16.1.3 Overview of Costs

The stream of future costs is expressed in constant 2024 dollars. Proposed Project costs include new and rehabilitation construction, ROW acquisition, and potential terrestrial ecology mitigation measures. Additional mitigation measures, such as stormwater management and potential noise barrier, are already included within the new construction costs estimated and will be further evaluated in the detailed design phase outside of the EIA. Construction is anticipated to occur in phases, with improvements planned in 2026, 2036, 2046, and 2060. Rehabilitation spending is expected to occur in five years: 2026, 2036, 2046, 2060, and 2074. There are no new construction costs for the Future No-Build condition.

As discussed in **Chapter 6: Proposed Project – Engineering Features**, there are two primary conceptual design options under consideration for the Proposed Project, each representing a different approach to balancing initial construction costs, storm resiliency, and long-term maintenance expenditures. The CBA compares these options to assess both the upfront financial investment and the anticipated lifecycle costs associated with each option.

The Excellent Fit, the initial conceptual design referred to throughout this ES, involves a higher initial cost due to its elevated profile height, expanded drainage structures, and more robust storm-resilient infrastructure. These upfront investments are aimed at minimising long-term risks and reducing ongoing maintenance costs. The higher elevation helps prevent roadway overtopping during major storm events, while the larger bridges and culverts are designed to maintain hydraulic connectivity and reduce debris-related blockages. As a result, the Excellent Fit is expected to require fewer post-storm repairs; experience fewer service interruptions; and provide long-term cost savings through reduced emergency response, maintenance frequency, and infrastructure rehabilitation. Details of the costs for the Excellent Fit can be found in **6.2.3: Total Costs**.

The Acceptable Fit, by contrast, offers a lower-cost option of the Proposed Project in terms of initial capital expenditure. This is achieved through a lower profile elevation, smaller culverts, and a more streamlined design. However, these cost savings come with trade-offs. The lower profile increases the likelihood of overtopping during severe storms, and erosion or drainage blockages may require more frequent maintenance and emergency repairs. Over time, these recurring costs may offset some of the initial savings. The Acceptable Fit also includes several optional features—the Will T Connector, sidewalks, a micromobility path, and dedicated transit lanes—that are accounted for in the CBA but are not required at the outset. These elements offer flexibility for future upgrades, allowing capital investment to be phased or deferred based on evolving transportation needs and available funding. Details of the costs for the Acceptable Fit can be found in **Section 6.3.2: Acceptable Fit Design Option**.

All cost totals have subtracted the Future No-Build condition anticipated costs for comparison. Original construction costs for the Future No-Build and Proposed Project can be found in **Chapter 6: Proposed Project – Engineering Features**. Construction and mitigation costs presented in **Tables 16-1a** through **16-1d** include 20% contingency for the Proposed Project and 40% contingency for the Future No-Build condition. The contingency applied to the projects is a risk factor intended to account for unknowns in the estimated costs that each alternative may encounter. The lower contingency applied to the Proposed Project reflects that some preliminary design work has been completed, including the development of a preliminary drainage layout and roadway alignment based on available data. In comparison, the Future No-Build option along the existing coastal roadway has greater uncertainty regarding the specific elements that may require additional rehabilitation or ongoing maintenance costs over the lifecycle period. Additional field survey and detailed inspection of the existing corridor would be required to fully assess the condition of the roadway, drainage systems, and other infrastructure components, resulting in a higher contingency factor being applied.

Table 16-1a: Road Construction and Maintenance, Mitigation, Right of Way Costs (USD 2024 $M)

	Year	New Construction Cost Subtotal	Rehab Construction Cost Subtotal	ROW Cost	Potential Terrestrial Ecology Mitigation Cost	Total Road Cost Undiscounted	Total Road Cost Discounted
Proposed Project minus Future No-Build	2024	-	-	20.33	-	20.33	19.65
	2026	262.83	-18.85	-	15.59	259.56	234.12
	2036	158.05	109.51	-	9.35	276.92	177.06
	2046	96.60	56.06	-	3.12	155.77	70.61
	2060	71.06	125.20	-	3.12	199.37	66.79
	2074	14.43	57.90	-	-	72.33	16.02
	Total	**602.97**	**329.81**	**20.33**	**31.17**	**984.28**	**584.23**

Table 16-1b: Road Construction and Maintenance, Mitigation, Right of Way Costs (2024 CI$M)

	Year	New Construction Cost Subtotal	Rehab Construction Cost Subtotal	ROW Cost	Potential Terrestrial Ecology Mitigation Cost	Total Road Cost Undiscounted	Total Road Cost Discounted
Proposed Project minus Future No-Build	2024	-	-	17.09	-	17.09	16.51
	2026	220.86	-15.84	-	13.10	218.12	196.73
	2036	132.82	92.03	-	7.86	232.70	148.79
	2046	81.17	47.11	-	2.62	130.90	59.33
	2060	59.71	105.21	-	2.62	167.54	56.12
	2074	12.13	48.66	-	-	60.78	13.46
	Total	**506.70**	**277.15**	**17.09**	**26.20**	**827.13**	**490.95**

Table 16-1c: Acceptable Fit Road Construction and Maintenance, Mitigation, Right of Way Costs (USD 2024 $M)

	Year	New Construction Cost Subtotal	Rehabilitation Construction Cost Subtotal	ROW Cost	Potential Terrestrial Ecology Mitigation Cost	Total Road Cost Undiscounted	Total Road Cost Discounted
Proposed Project minus Future No-Build	2024	-	-	20.33	-	20.33	19.65
	2026	95.60	-18.85	-	15.59	92.34	83.29
	2036	86.27	0.82	-	9.35	96.43	61.66
	2046	46.36	26.00	-	3.12	75.48	34.21
	2060	55.52	76.95	-	3.12	135.59	45.42
	2074	11.59	56.85	-	-	68.44	15.16
	Total	**295.34**	**141.77**	**20.33**	**31.17**	**488.61**	**259.38**

Table 16-1d: Acceptable Fit Road Construction and Maintenance, Mitigation, Right of Way Costs (2024 CI$M)

	Year	New Construction Cost Subtotal	Rehabilitation Construction Cost Subtotal	ROW Cost	Potential Terrestrial Ecology Mitigation Cost	Total Road Cost Undiscounted	Total Road Cost Discounted
Proposed Project minus Future No-Build	2024	-	-	17.09	-	17.09	16.51
	2026	80.34	-15.84	-	13.10	77.60	69.99
	2036	72.49	0.69	-	7.86	81.04	51.82
	2046	38.96	21.85	-	2.62	63.43	28.75
	2060	46.65	64.67	-	2.62	113.94	38.17
	2074	9.74	47.77	-	-	57.51	12.74
	Total	**248.18**	**119.13**	**17.09**	**26.20**	**410.60**	**217.97**

Costs for the solar array are not included within **Tables 16-1a** through **16-1d**. Detailed information on costs associated with the solar array can be found in **Appendix E :- Shortlist [Alternatives] Evaluation: Attachment J – Cost-Benefit Analysis – Assessment of Alternatives**.

16.1.4 Overview of Benefits

The monetised benefits of the Proposed Project Excellent Fit and Acceptable Fit conceptual design options are assumed equal. Therefore, the benefits within this section are applicable to both the Excellent Fit and Acceptable Fit conceptual design options.

16.1.4.1 Traffic

Benefits from transportation efficiency accrue in each year from 2026 to 2074. Benefits primarily stem from travel time savings enabled by the improvements planned in 2026, 2036, 2046, and 2060. The analysis uses travel model outputs from the GCM for three conditions in each analysis year: 1) the Full No-Build, which only includes the planned future roadway infrastructure as detailed in **Chapter 7: Transportation and Mobility**; 2) the Full Build, which includes all planned roadway infrastructure and the Proposed Project improvements scheduled for that project opening year; and 3) a Partial Build condition that contains the planned roadway infrastructure and the Proposed Project improvements complete in prior years, which allows measurement of system performance in the analysed year without additional improvements. In project opening years, the Full No-Build and the Full Build conditions are compared. In intervening years, the transportation system performance is estimated based on interpolation using the Partial Build outputs. This allows accurate representation of investment effects in the years beyond project opening given expected changes in demographics, economics, land use, and travel patterns.

The GCM accounts for the following modes: private car, taxi, transit bus, school bus, truck transportation, walking, and biking. Short-term visitors' private car use is assigned to the transportation network separately as they have different travel behaviour than local private car users.

The GCM includes data on the number of trips made for commuting purposes in the AM and PM peak periods. For all other trip purposes, and for off-peak travel, values from the WebTAG were used to estimate the share of travel for each trip purpose, resulting in the following assumptions:

- Business – 16.5% of AM travel, 11.8% of PM travel, and 16.5% of off-peak travel. This category includes drivers in an official work vehicle or traveling while on the clock (dump truck, WAC truck, Mosquito Research and Control Unit truck, plumbers, carpenters, business meetings, etc.)
- Non-Business: Commuting – 60.6% of AM, 46.8% of PM, and 11.8% of off-peak travel. The share of AM and PM travel in this category varies between years and scenarios. This category represents travellers commuting to or from their place of work.
- Non-Business: Other – 22.9% of AM travel, 41.4% of PM travel, 71.7% of off-peak travel. This category includes all travel aside from business or commuting (groceries, education, tourism, social activities, etc.).

Travel performance was modelled during the AM peak hour, the PM peak hour, and under free-flow conditions within the GCM. The AM peak hour was expanded by a factor of two and PM peak hour by a factor of three to account for the extended congested travel periods experienced on Grand Cayman. After determining the share of daily traffic accounted for in the AM and PM peak periods, the remainder of daily traffic was assumed to experience free-flow conditions. Transportation modelling performed for this EWA Extension EIA focused on the critical AM and PM peaks; no modelling was available to indicate how travel patterns differ during the midday or night-time periods. Assuming that off-peak conditions operate at free-flow speeds provides a conservative estimate of travel performance, as it underestimates the impact of existing congestion. Although congestion is likely to occur outside the AM and PM peak travel periods, it is not accounted for in this assumption. Daily travel performance is annualized using a factor of 365 assuming that tourism travel and personal trips would continue on the weekends, even with reduced school and commute travel. Traffic data was developed as part of the traffic evaluation, contributing to multiple components within the process including the CBA. See **Chapter 7:**

Transportation and Mobility for additional information regarding the traffic volumes and analysis.

The increased accessibility provided by the Proposed Project is estimated to result in additional vehicular miles travelled and associated operating costs such as fuel consumption and vehicle wear and tear. The benefits that users would gain from this improved access are not quantified, which significantly underestimates the project's overall benefits. However, users would gain access to more desirable work, education, shopping, and other welfare benefits that improve their quality of life.

In addition to estimating travel time savings from reduced delay created by the Proposed Project, the travel benefits methodology also considers how travellers plan their trips for the possibility of additional delay due to congested conditions. Buffer time savings were also estimated, where buffer time is the extra time required to leave early so that the traveller is reliably on-time 19 of every 20 trips. This reliability is especially important for freight movement efficiencies. The buffer time was estimated based on a relationship between network-level congestion statistics and reliability developed by consulting firms EBP U.S., Inc. and Cambridge Systematics in the 2nd Strategic Highway Research Program.[10]

As documented in **Chapter 7: Transportation and Mobility**, the RCIPS provided a compilation of motor vehicle accident statistics in Grand Cayman by district from 2012 to 2022, as well as a list of road fatalities from 2018 to 2020. However, this data was insufficient to conduct a detailed quantitative safety analysis for this project. Therefore, safety benefits were not quantified due to the limited location-specific crash data.

The GCM uses different vehicle occupancy factors based on the trip purpose and its mode. The CBA uses the following vehicle occupancy rates from the travel model to determine the number of person trips, miles, and hours travelled in each year and scenario:

- Business trips: 1.66 passengers per vehicle
- Commute trips: 1.10 passengers per vehicle
- Personal trips: 1.75 passengers per vehicle
- Visitors: 2.90 passengers per vehicle

Different values of time were applied based on trip purposes and modes in accordance with standard CBA practice. For business travellers, the value of time was assumed to be 1.45 times the mean hourly wage of Grand Cayman residents, reflecting the additional benefits and compensation that employers provide beyond wages. This is the standard multiplier the USDOT uses to calculate the value of business traveller time savings (US Department of Transportation, 2014) and is derived using the ratio of total employer costs to employee compensation from the U.S. Bureau of

[10] Estimates created during the course of research for the C11 project. Project noted here and other deliverables available from the Transportation Research Board: AASHTO - Strategic Highway Research Program 2 - EconWorks Transportation Project Impact Case Studies (C03) and Tools for Assessing Wider Economic Benefits (C11)

Labour Statistics (US Bureau of Labor Statistics, 2024). The value of commuter and personal time was then calculated relative to the value of business time using ratios from WebTAG. The values of time used in the analysis were:

- Business time: $42.47 per hour USD (CI$35.69 per hour)
- Commuting time: $15.13 per hour USD (CI$12.71 per hour)
- Personal time: $6.91 per hour USD (CI$5.81 per hour)

Additional monetisation factors for the travel benefits analysis are presented in **Table 16-2**. Discounted travel benefits are summarized in **Tables 16-3a** and **16-3b**.

Table 16-2: Travel Benefits Monetisation Factors

Measure	Adjustment Factor	
Vehicle Operating Cost per VMT – Passenger Car	US $0.166	CI $0.140
Vehicle Operating Cost per VMT – Light-Duty EV	US $0.149	CI $0.125
Vehicle Operating Cost per VMT – Taxi	US $0.182	CI $0.153
Vehicle Operating Cost per VMT – Passenger Bus	US $1.548	CI $1.301
Vehicle Operating Cost per VMT – All Trucks	US $0.600	CI $0.504
Grand Cayman Fuel Price - Regular	US $5.63/gallon	CI $4.73/gallon
Grand Cayman Fuel Price – Diesel	US $5.58/gallon	CI $4.69/gallon
Fuel per mile – Passenger Car	0.0435 gallons	
Fuel per mile – Light-Duty Electric Vehicle	0.3527 kWh	
Fuel per mile – Bus (diesel)	0.2433 gallons	
Fuel per mile – All Trucks	0.1504 gallons	

Table 16-3a: WebTAG Transportation Economic Efficiency Table (USD 2024 $M)

Benefit	Low Growth	Medium Growth
Non-business: Commuting		
User Travel Time	217.32	169.56
Vehicle Operating Cost	-9.82	-8.06
Net Non-Business Benefits: Commuting	207.30	161.50
Non-business: Other		
User Travel Time	65.73	82.29
Vehicle Operating Cost	-118.69	-101.38
Net Non-Business Benefits: Other	-52.96	-19.09
Business		
User Travel Time	483.05	429.80
Vehicle Operating Cost	-25.27	-25.55
Net Business Impact	457.78	404.25
Total		
Present Value of Transport Economic Efficiency Benefits*	612.12	546.66
Present Value of Transportation Benefits Including Reliability	1,028.01	951.65

**WebTAG Transport Economic Efficiency Benefits do not account for additional reliability benefits included in tabulation of total transportation benefits. Total transportation benefits are presented in the final row for comparison with Transportation Economic Efficiency (TEE) benefits.*

Table 16-3b: WebTAG Transportation Economic Efficiency Table (2024 CI$M)

Benefit	Low Growth	Medium Growth
Non-business: Commuting		
User Travel Time	182.62	142.49
Vehicle Operating Cost	-8.25	-6.77
Net Non-Business Benefits: Commuting	174.20	135.71
Non-business: Other		
User Travel Time	55.24	69.15
Vehicle Operating Cost	-99.74	-85.19
Net Non-Business Benefits: Other	-44.5	-16.04
Business		
User Travel Time	405.92	361.18
Vehicle Operating Cost	-21.24	-21.47
Net Business Impact	384.69	339.71
Total		
Present Value of Transport Economic Efficiency Benefits*	514.39	459.38
Present Value of Transportation Benefits Including Reliability	863.87	799.71

**WebTAG Transport Economic Efficiency Benefits do not account for additional reliability benefits included in tabulation of total transportation benefits. Total transportation benefits are presented in the final row for comparison with Transportation Economic Efficiency (TEE) benefits.*

16.1.4.2 Noise

Noise benefits occur from 2026 to 2074, and their valuations are based on the WebTAG approach to incorporating noise pollution into economic analysis (Department for Environment, Food & Rural Affairs, 2014; UKDOT, 2024c). The WebTAG Unit A3 Noise Assessment Workbook automatically calculates the monetary value of changes in noise per number of households affected under the Proposed Project in two population growth/land use scenarios (low, medium) compared to the Future No-Build condition (UKDOT, 2024e). WebTAG assigns a monetary value to each shift from one decibel range to another based on research of health impacts of these changes. These standard appraisal values are found in WebTAG Data Book Table A3.1 and are also embedded in the WebTAG Noise Workbook.

The noise workbook calculates values for five types of noise impacts: sleep disturbance, amenity loss, acute myocardial infarction (AMI or heart attack) risk, stroke risk, and dementia risk. Noise decibel values were provided for the Proposed Project and Future No-Build condition. Additional details regarding noise decibel values and the overall noise evaluation for the Proposed Project can be found in **Chapter 9: Noise and Vibration**.

The environmental noise impacts of the Proposed Project were determined by evaluating 1,436 households in the study area. Future noise levels for these households were projected for the Future No-Build and the Proposed Project in construction years 2026, 2036, 2046, and 2074. For each year, the number of households moving from one decibel range under Future No-Build conditions to a higher or lower range under the Proposed Project was calculated using the WebTAG noise Assessment Workbook.

WebTAG Data Book Table A3.1 contains the annual value of the impact of a 1 decibel change in noise level on a household, assuming an average household size of 2.3 people. To adjust to the estimated household size within Bodden Town District, the analysis assumed an average household size of 2.7. Multipliers were then applied to convert British Pounds (GBP) to USD and CI$, adjust to 2024 prices, and to reflect the Grand Cayman wage rate. These results were added to the CBA matrix, and benefits were discounted to constant 2024 dollars.

The WebTAG Noise Workbook automatically calculates the total monetary value of the shift from Future No-Build to the Proposed Project in the years 2026, 2036, 2046 and 2074. The noise benefits for years between build phases were interpolated using compound annual VMT growth rates from the travel model. A reverse VMT growth rate from 2074 noise benefits was applied to interpolate 2060-2073 benefits. These values are listed in constant 2024 dollars in **Table 16-4** and **Table 16-5**.

Table 16-4: Noise Benefits by Build Year

Year	Scenario	Proposed minus No-Build Discounted Sum (US 2024 $M)	Proposed minus No-Build Discounted Sum (2024 CI$M)
2026	Low & Medium	-1.06	-0.89
2036	Low & Medium	-1.22	-1.03
2046	Low & Medium	-0.91	-0.77
2060	Low	-0.56	-0.47
2060	Medium	-0.49	-0.41
2074	Low	-0.50	-0.42
2074	Medium	-0.47	-0.40

Table 16-5: Noise Benefits by Growth Scenario

Scenario	Sum 2026-2074	Discounted Sum (US 2024 $M)	Discounted Sum (2024 CI$M)
Low Growth	-61.84	-44.39	-37.30
Medium Growth	-61.10	-44.01	-36.99

Compound annual VMT growth rates from the travel model were used to estimate noise benefits in the years between each build phase. To interpolate 2060 noise benefits, a reverse VMT growth rate to 2074 noise benefits was applied for the years 2060 to 2073.

16.1.4.3 Carbon Monetisation

WebTAG's recommended central factor carbon cost (WebTAG Data Book A3.4 and Unit A3) was used to monetise the benefits of carbon sequestration, one-time construction carbon emissions (peat removal and amenity value loss), traffic-related carbon emissions, solar-related carbon emissions, and bulk material, construction tailpipe, and commuter/delivery tailpipe emissions. The WebTAG values were converted from GBP to USD and CI$ and adjusted to constant 2024 dollars. **Table 16-6** summarizes the values used to monetise carbon sequestration and emissions in the analysis.

Table 16-6: Carbon Monetisation Values

Year	WebTAG Carbon Values, £ per tCO_2e (2010£)	Carbon Values, $ per tCO_2e (US 2024$)	Carbon Values, $ per tCO_2e (CI$ 2024)
2026	214.49	392.26	329.63
2030	227.86	416.71	350.18
2040	265.03	484.69	407.3
2050	307.58	562.50	472.69
2060	356.96	652.81	548.58
2070	414.27	757.62	636.66
2074	439.69	804.11	675.72

16.1.4.4 Carbon Emissions

Emissions were estimated for the AM and PM peak hours across 2026, 2036, 2046 and 2074 using the MOVES model. Details regarding this methodology can be found in **Chapter 10: Greenhouse Gas Emissions**. These values are summarized below in **Table 16-7** and **Table 16-8**.

Compound annual VMT growth rates were used to estimate emissions between construction phases. To interpolate 2060 carbon emissions, a reverse VMT growth rate was applied to the projected 2074 emissions to estimate emissions from 2060 to 2073. Because 2060 emissions were not evaluated in the MOVES model, this is the best available method to estimate how emissions may change following 2060 road improvements.

Future No-Build carbon emissions were then subtracted from Proposed Project emissions, and multipliers were applied to reflect two congested traffic hours in the morning and three congested traffic hours in the afternoon.

Table 16-7: Future No-Build Peak Hour Traffic-Related Carbon Emissions

Year	Scenario	AM Congested tCO2e	PM Congested tCO2e	Total Congested tCO2e
2026	Low & Medium	53,807	123,925	177,733
2036	Low & Medium	66,811	139,765	206,576
2046	Low & Medium	67,265	140,873	208,138
2060	Low	84,547	142,830	227,378
2060	Medium	101,937	191,441	293,378
2074	Low	87,681	157,929	245,610
2074	Medium	115,220	228,705	343,925

Table 16-8: Proposed Project Peak Hour Traffic-Related Carbon Emissions

Year	Scenario	AM Congested tCO2e	PM Congested tCO2e	Total Congested tCO2e
2026	Core	64,534	138,205	202,739
2036	Core	68,357	135,887	204,244
2046	Core	69,396	129,396	198,792
2060	Low	97,179	167,350	264,530
2060	Medium	92,942	161,211	254,153
2074	Low	101,509	185,041	286,550
2074	Medium	104,890	192,591	297,480

Carbon emissions are monetised by multiplying MT in each year by the corresponding central factor carbon price, as referenced in **Table 16-6**. Benefits (or savings) are recorded as positive values. Disbenefits or increased monetary value of emissions compared to the Future No-Build condition, are recorded as negative values. The discounted sum of emissions values over the project's lifespan is positive for the medium growth scenario only, reflecting overall savings due to more efficient travel, as shown in **Table 16-9a** and **16-9b**. The discounted sum is negative for the low growth scenario, reflecting an overall loss due to the additional travel driven by travellers taking advantage of improved accessibility to desirable destinations, outweighing the efficiency improvements from reduced congestion.

Table 16-9a: Proposed Project minus No-Build Value of Traffic-Related Carbon Emissions (USD 2024 $M)

Scenario	2026 Discounted Value	2036 Discounted Value	2046 Discounted Value	2060 Discounted Value	2074 Discounted Value	Discounted Sum
Low Growth	-8.85	0.68	2.25	-8.12	-7.29	-169.23
Medium Growth	-8.85	0.68	2.25	8.58	8.27	74.89

Table 16-9b: Proposed Project minus No-Build Value of Traffic-Related Carbon Emissions (CI 2024 $M)

Scenario	2026 Discounted Value	2036 Discounted Value	2046 Discounted Value	2060 Discounted Value	2074 Discounted Value	Discounted Sum
Low Growth	-7.43	0.57	1.89	-6.83	-6.13	-142.21
Medium Growth	-7.43	0.57	1.89	7.21	6.95	62.94

16.1.4.5 Peat Removal

Tables 16-10a and **16-10b** display the estimated peat removal carbon emissions related to construction of the Proposed Project. This benefit is negative, reflecting a monetary loss due to carbon emissions during 2026 construction under all scenarios.

Table 16-10a: Estimated Peat Removal Carbon Emissions from Construction (2026), USD

Build Condition	tCO2e	2026 Value (USD $M)	Discounted Sum (USD 2024 $M)
Proposed Project	73,589	-28.87	-26.04

Table 16-10b: Estimated Peat Removal Carbon Emissions from Construction (2026), CI$

Build Condition	tCO2e	2026 Value (CI $M)	Discounted Sum (CI 2024 $M)
Proposed Project	73,589	-24.26	-21.88

16.1.4.6 Carbon Sequestration Loss

The studies conducted in **Chapter 13: Terrestrial Ecology** tabulated the annual metric tonne loss of ecosystem services from 2026-2074 (carbon sequestration) that was estimated to occur under the Proposed Project compared to the Future No-Build condition. These values are summarized in **Tables 16-11a** and **16-11b**. These estimated values were monetised according to the WebTAG carbon pricing schedule in **Table 16-6**, adjusted for constant 2024 dollars, and multiplied by -1 to reflect a loss (disbenefit) in the analysis. These benefits are negative for all growth/land use scenarios, reflecting a monetary loss due to carbon sequestration loss. For the evaluation, all loss of ecosystem services was assumed to occur in the initial construction phase (2024-2025) to provide a conservative estimate on emissions.

Table 16-11a: Annual Carbon Sequestration Loss, USD

Build Condition	Annual tCO_2e	Sum 2026-2074 (USD 2024 $M)	Discounted Sum (USD 2024 $M)
Proposed Project	424.2	-11.95	-5.12

Table 16-11b: Annual Carbon Sequestration Loss, CI$

Build Condition	Annual tCO_2e	Sum 2026-2074 (CI 2024 $M)	Discounted Sum (CI 2024 $M)
Proposed Project	424.2	-10.04	-4.30

16.1.4.7 Bulk Material, Construction Tailpipe, and Commuter/Delivery Tailpipe Emissions

The EWA EIA project team tabulated the annual metric tonne loss of carbon emissions estimated to occur from project worker commutes and delivery vehicle tailpipes, construction equipment tailpipes, and from handling bulk material. Details regarding this methodology can be found in **Chapter 10: Greenhouse Gas Emissions**. These values are summarized in **Tables 16-12a** and **16-12b** and applicable to both the Low and Medium Growth scenarios. These estimated values were monetised according to the WebTAG carbon pricing schedule in **Table 16-6**, adjusted for constant 2024 dollars, and multiplied by -1 to reflect a loss (disbenefit) in the analysis. This results in an overall negative benefit, or loss, due to additional emissions in each build year.

Table 16-12a: Bulk Material, Construction Tailpipe, and Commuter/Delivery Tailpipe Emissions, USD

Year	Proposed minus No-Build tCO_2e	Value of Emissions (USD 2024 $M)	Discounted Value of Emissions (USD 2024 $M)
2026	33,402	-13.10	-11.82
2036	27,702	-12.64	-8.08
2046	19,276	-10.22	-4.63
2060	25,360	-16.55	-5.55
2074	14,566	-11.71	-2.59
Total	**120,305**	**-64.22**	**-32.67**

Table 16-12b: Bulk Material, Construction Tailpipe, and Commuter/Delivery Tailpipe Emissions, CI$

Year	Proposed minus No-Build tCO_2e	Value of Emissions (CI 2024 $M)	Discounted Value of Emissions (CI 2024 $M)
2026	33,402	-11.01	-9.93
2036	27,702	-10.62	-6.79
2046	19,276	-8.58	-3.89
2060	25,360	-13.91	-4.66
2074	14,566	-9.84	-2.18
Total	**120,305**	**-53.97**	**-27.45**

16.1.4.8 Non-carbon Emissions

Traffic-related non-carbon (NOx, SO2, VOC, and PM2.5) emissions were estimated during peak travel hours as MT emitted in construction years 2026, 2036, 2046, and 2074. Details regarding the methodology can be found in **Section 10.3.2: Operation Phase** and **Appendix I.3 – Critical Pollutants Analysis Results**. These values are summarized below in **Table 16-13** and **Table 16-14**.

To interpolate non-carbon emissions, the same methodology was used as described in the Carbon Emissions section assuming compound annual VMT growth rates in years between construction phases and 2060. Multipliers were then applied to the AM and PM peak hour emissions to reflect two congested traffic hours in the morning and three congested traffic hours in the afternoon.

Table 16-13: No-Build Peak Hour Traffic-Related Non-carbon Emissions (Metric Tonnes)

Year	Scenario	NOx	SO2*	VOC	PM2.5
2026	Low & Medium	440.47	9.08	146.87	14.69
2036	Low & Medium	130.26	0.88	30.57	5.07
2046	Low & Medium	31.67	0.90	15.3	0.99
2060	Low	130.26	0.88	30.57	5.07
2060	Medium	43.53	44.47	38.37	2.54
2074	Low	32.3	37.3	26.69	2.00
2074	Medium	51.25	52.31	45.29	2.99

**Sulphur dioxide*

Table 16-14: Proposed Project Peak Hour Traffic-Related Non-carbon Emissions (Metric Tonnes)

Year	Scenario	NOx	SO2	VOC	PM2.5
2026	Low & Medium	520.91	10.76	156.49	16.51
2036	Low & Medium	117.17	0.87	27.08	4.42
2046	Low & Medium	24.76	0.87	12.76	0.92
2060	Low	37.07	39.57	32.22	2.21
2060	Medium	34.89	38.15	30.43	2.12
2074	Low	40.11	42.86	34.87	2.39
2074	Medium	40.82	44.65	35.64	2.48

Carbon emissions are monetised by multiplying MT in each year by the corresponding monetisation values (US Department of Transportation, 2023), as referenced in **Table 16-6**. Benefits (or savings) are recorded as positive values. Disbenefits or increased monetary value of emissions compared to the Future No-Build condition is recorded as negative values. The discounted sum of emissions values over the project's lifespan is negative for all growth scenarios, reflecting overall loss, as shown in **Tables 16-15a** and **16-15b**.

Table 16-15a: Proposed Project minus No-Build Value of Traffic-Related Non-carbon Emissions, (USD 2024 $M)

Scenario	2026 Discounted Value	2036 Discounted Value	2046 Discounted Value	2060 Discounted Value	2074 Discounted Value	Discounted Sum
Low Growth	-3.53	0.84	0.17	-0.55	-0.51	-34.75
Medium Growth	-3.53	0.84	0.17	0.67	0.68	-16.55

Table 16-15b: Proposed Project minus No-Build Value of Traffic-Related Non-carbon Emissions, (CI 2024 $M)

Scenario	2026 Discounted Value	2036 Discounted Value	2046 Discounted Value	2060 Discounted Value	2074 Discounted Value	Discounted Sum
Low Growth	-2.96	0.71	0.14	-0.46	-0.43	-29.20
Medium Growth	-2.96	0.71	0.14	0.56	0.57	-13.91

16.1.4.9 Amenity Value Loss

Ecosystem services from amenity value are measured in the number of houses and correlating amenity value to mangroves based on the 2020 Cayman Islands Ecosystem Accounting. The studies conducted in **Chapter 13: Terrestrial Ecology** included an estimate of a one-time loss of Amenity Value to occur in 2026 using 2017 USD. These values were converted to constant 2024 USD and multiplied values by -1 to reflect a loss (disbenefit) in the CBA. This benefit is negative under all growth/land use scenarios, reflecting a monetary loss due to amenity value loss. These values are reflected below in **Tables 16-16a** and **16-16b**.

Table 16-16a: Amenity Loss Benefits (USD 2024 $M)

Build Condition	2026 Sum	Discounted Sum
Proposed Project	-12.62	-11.38

Table 16-16b: Amenity Loss Benefits (CI 2024 $M)

Build Condition	2026 Sum	Discounted Sum
Proposed Project	-10.61	-9.56

16.2 CBA Results

The following provides summaries of the CBA results for the elements described in the previous sections of this chapter and detailed in **Appendix M – Cost-Benefit Analysis**. **Table 16-17** provides the overall CBA results. **Table 16-18** documents sensitivity results around how future benefits and costs are valued. **Table 16-19**, **Table 16-20**, and **Table 16-21** provide summaries of the estimated monetised costs and benefits for each of the elements included in the WebTAG analysis. A BCR above 1.0 represents the anticipated benefits being greater than the anticipated costs. The low and medium population growth/land use scenarios are anticipated to result in greater benefit than cost over the project lifespan (2026 to 2074).

Project costs remain the same under each growth scenario but vary under the Excellent Fit and Acceptable Fit options. Several project benefit values also remain the same across scenarios, including solar array electricity and emissions savings, amenity value loss, bulk material and tailpipe emissions from construction activities, other one-time construction emissions, and carbon sequestration impact. Travel benefits, emissions from traffic, and noise benefits change according to the level of anticipated travel under each growth scenario.

The monetary value of benefits is assumed equal for both the Proposed Project Excellent Fit and Acceptable Fit options, and highest under the medium growth scenario is highest, resulting in the highest BCR of the 2074 population growth/land use scenarios. The Excellent Fit option in the medium growth scenario shows an NPV that is 60% higher than under the low growth scenario.

The Acceptable Fit option in the medium growth scenario shows an NPV that is 31% higher than under the low growth scenario.

The Excellent Fit internal rate of return (IRR) is 2% under the low and medium growth scenarios. The Acceptable Fit IRR is 4% under the low growth scenario and 5% under the medium growth scenario.

This CBA chapter does not evaluate the Proposed Project anticipated costs and benefits under the High Growth scenario. Without significant transportation investments, the 2074 High Growth scenario would lead to severe congestion and limited travel options, requiring broader infrastructure improvements to support such growth. As these additional improvements are not in the scope of this analysis, High Growth scenario results are not included in **Tables 16-17a** and **16-17b**.

Table 16-17a: Proposed Project minus No-Build CBA Results Summary (USD 2024 $M)

Scenario	Present Value Costs	Present Value Benefits	NPV (Benefit – Cost)	BCR*	IRR
Excellent Fit Low Growth	620.27	904.47	284.19	1.5	2%
Excellent Fit Medium Growth	620.27	1,090.80	470.52	1.8	2%
Acceptable Fit Low Growth	295.43	904.47	609.04	3.1	4%
Acceptable Fit Medium Growth	295.43	1,090.80	795.37	3.7	5%

**A BCR above 1.0 represents the anticipated benefits being greater than the anticipated costs*

Table 16-17b: Proposed Project minus No-Build CBA Results Summary (CI 2024 $M)

Scenario	Present Value Costs	Present Value Benefits	NPV (Benefit – Cost)	BCR*	IRR
Excellent Fit Low Growth	521.24	760.06	238.82	1.5	2%
Excellent Fit Medium Growth	521.24	916.64	395.40	1.8	2%
Acceptable Fit Low Growth	248.26	760.06	511.80	3.1	4%
Acceptable Fit Medium Growth	248.26	916.64	668.38	3.7	5%

**A BCR above 1.0 represents the anticipated benefits being greater than the anticipated costs*

Tables 16-18a and **16-18b** present results of a sensitivity analysis using 2% and 5% discount rates in addition to the WebTAG discount schedule (3.5% for 30 years and 3% after that) to account for uncertainty in stakeholders' perception of future benefits and costs. A lower discount rate would be used if people highly value how their future selves and future generations are impacted by the project. A lower discount rate would be used if people prioritise current conditions. It is important to use consistent discount rates when comparing choices that could have trade-offs such as in the use of government funds.

Excellent Fit NPVs are positive using the 2% and WebTAG discount rates under the low growth scenario, and BCRs are greater than one. The 5% discount rate produces a negative Excellent Fit NPV and a BCR just under one.

Acceptable Fit NPVs are positive using all three discount schedules under the low and medium growth scenarios. BCRs are all greater than one.

Tables 16-18a and **16-18b** also present results of the CBA analysis including and excluding the solar array component of the project.

For the Excellent Fit option, excluding the costs and benefits of the solar array lowers the Proposed Project NPV by 58% in the Low Growth scenario and 35% in the Medium Growth scenario using WebTAG discount rates. The NPV changes sign from positive to negative in the Medium Growth scenario using a 5% discount rate when excluding the solar array from the analysis. NPVs do not change signs when excluding the solar array using other discount rates under either growth scenario. BCRs greater than one remain without the solar array using 2% and WebTAG discount rates. Using the 5% rate, the BCR drops below one in the medium growth scenario without the solar array.

For the Acceptable Fit option, excluding the costs and benefits of the solar array lowers the Proposed Project NPV by 24% in the Low Growth scenario and 19% in the Medium Growth scenario using WebTAG discount rates. NPVs remain positive and BCRs greater than one under all discount rates when excluding the solar array from the analysis.

At a lower discount rate, both the Excellent Fit and Acceptable Fit options appears to offer similar benefits that exceed costs for all discount rates under the low and medium growth scenarios, with or without the solar array (BCRs greater than 1.0). At a high discount rate, both options show fewer benefits compared to costs (lower BCRs) because many of the costs are incurred earlier in the analysis period, enabling more moderately priced improvements in later years. The benefits of both options are much larger in the future when traffic needs have become even more severe than today. Stakeholders who value making the investments today that address expected future mobility, accessibility, safety, and emissions impacts, prefer a lower discount rate to reflect this.

Table 16-18a: Sensitivity Analysis Results (USD 2024 $M)

Proposed minus No-Build condition	Metric	2% Discount Rate	WebTAG Discount Schedule	5% Discount Rate
Excellent Fit Low Growth Transportation + Solar	NPV (USD 2024 $M)	638.86	284.19	-28.43
	BCR	1.9	1.5	0.9
	IRR	3%	2%	0%
Excellent Fit Low Growth Transportation Only	NPV (USD 2024 $M)	391.95	120.20	-108.35
	BCR	1.6	1.2	0.8
	IRR	2%	1%	-1%
Excellent Fit Medium Growth Transportation + Solar	NPV (USD 2024 $M)	911.41	470.52	45.48
	BCR	2.2	1.8	1.1
	IRR	3%	2%	0%
Excellent Fit Medium Growth Transportation Only	NPV (USD 2024 $M)	664.50	306.53	-34.44
	BCR	1.9	1.5	0.9
	IRR	3%	2%	0%
Acceptable Fit Low Growth Transportation + Solar	NPV (USD 2024 $M)	1,018.94	609.04	248.69
	BCR	3.8	3.1	2.1
	IRR	6%	4%	3%
Acceptable Fit Low Growth Transportation Only	NPV (USD 2024 $M)	772.03	445.05	168.77
	BCR	3.4	2.7	1.8
	IRR	5%	4%	2%
Acceptable Fit Medium Growth Transportation + Solar	NPV (USD 2024 $M)	1,291.50	795.37	322.59
	BCR	3.8	3.7	2.4
	IRR	6%	5%	3%
Acceptable Fit Medium Growth Transportation Only	NPV (USD 2024 $M)	1,044.59	631.38	242.67
	BCR	4.3	3.4	2.2
	IRR	6%	4%	3%

Table 16-18b: Sensitivity Analysis Results (CI 2024 $M)

Proposed minus No-Build condition	Metric	2% Discount Rate	WebTAG Discount Schedule	5% Discount Rate
Excellent Fit Low Growth Transportation + Solar	NPV (CI 2024 $M)	536.86	238.82	-23.89
	BCR	1.9	1.5	0.9
	IRR	3%	2%	0%
Excellent Fit Low Growth Transportation Only	NPV (CI 2024 $M)	329.37	101.01	-91.05
	BCR	1.6	1.2	0.8
	IRR	2%	1%	-1%
Excellent Fit Medium Growth Transportation + Solar	NPV (CI 2024 $M)	765.89	395.40	38.22
	BCR	2.2	1.8	1.1
	IRR	3%	2%	0%
Excellent Fit Medium Growth Transportation Only	NPV (CI 2024 $M)	558.41	257.59	-28.94
	BCR	1.9	1.5	0.9
	IRR	3%	2%	0%
Acceptable Fit Low Growth Transportation + Solar	NPV (CI 2024 $M)	856.26	511.80	208.98
	BCR	3.8	3.1	2.1
	IRR	6%	4%	3%
Acceptable Fit Low Growth Transportation Only	NPV (CI 2024 $M)	648.77	373.99	141.82
	BCR	3.4	2.7	1.8
	IRR	5%	4%	2%
Acceptable Fit Medium Growth Transportation + Solar	NPV (CI 2024 $M)	1,085.29	668.38	271.09
	BCR	4.5	3.7	2.4
	IRR	6%	5%	3%
Acceptable Fit Medium Growth Transportation Only	NPV (CI 2024 $M)	877.80	530.57	203.92
	BCR	4.3	3.4	2.2
	IRR	6%	4%	3%

For clarity, some categories from the template WebTAG Analysis of Monetised Costs & Benefits (AMCB) worksheet are excluded in **Tables 16-19** through **16-21** because they were not relevant to the project or estimates were not feasible (UKDOT, 2024f). These categories include: Journey Quality, Physical Activity, Accidents, Wider Public Finances, and Broad Transport Budget. The Local Air Quality category is labelled as Non-carbon Emissions (VOCs, NO_X, SO_2, PM2.5).

Table 16-19a: Excellent Fit Proposed Project Low Growth WebTAG Analysis of (Discounted) Monetised Costs and Benefits Including Solar Array, USD

Proposed Project Excellent Fit Low Growth Monetised Costs and Benefits (USD 2024 $M)	
BENEFITS	
Noise	-44.39
Electric Cost Savings from Solar Canopy	81.85
Amenity Loss from Construction	-11.38
Total Emissions Benefits	-149.62
Subtotal - One-time Carbon Emissions from Construction	-26.04
Subtotal - Bulk Material Emissions	-32.67
Subtotal - Carbon Sequestration Impact	-5.12
Subtotal - Carbon Emissions from Traffic	-169.23
Subtotal - Carbon Emissions Savings from Solar Canopy	118.18
Subtotal – Non-carbon Emissions (NOx, SO2, VOC, PM2.5)	-34.75
Total Transportation Benefits	1,028.01
Subtotal - Economic Efficiency: Consumer Users (Commuting)	207.30
Subtotal - Economic Efficiency: Consumer Users (Other)	-52.96
Subtotal - Economic Efficiency: Business Users and Providers	457.78
Subtotal – Reliability	415.89
Present Value of Benefits (PVB)	904.47
COSTS	
Total New Construction Cost with Contingency	408.90
Total Rehab Construction Cost with Contingency	133.19
Potential Mitigation with Contingency	22.49
Right of Way Cost	19.65
Solar Canopy Cost	36.04
Present Value of Costs	620.27
OVERALL IMPACTS	
Net Present Value (NPV)	284.19
Benefit to Cost Ratio (BCR)*	1.5

**A BCR above 1.0 represents the anticipated benefits being greater than the anticipated costs*

Table 16-19b: Excellent Fit Proposed Project Low Growth WebTAG Analysis of (Discounted) Monetised Costs and Benefits Including Solar Array, CI$

Proposed Project Excellent Fit Low Growth Monetised Costs and Benefits (CI 2024 $M)	
BENEFITS	
Noise	-37.30
Electric Cost Savings from Solar Canopy	68.79
Amenity Loss from Construction	-9.57
Total Emissions Benefits	-125.73
Subtotal - One-time Carbon Emissions from Construction	-21.88
Subtotal - Bulk Material Emissions	-27.43
Subtotal - Carbon Sequestration Impact	-4.3
Subtotal - Carbon Emissions from Traffic	-142.21
Subtotal - Carbon Emissions Savings from Solar Canopy	99.31
Subtotal – Non-carbon Emissions (NOx, SO2, VOC, PM2.5)	-29.20
Total Transportation Benefits	863.87
Subtotal - Economic Efficiency: Consumer Users (Commuting)	174.2
Subtotal - Economic Efficiency: Consumer Users (Other)	-44.5
Subtotal - Economic Efficiency: Business Users and Providers	384.69
Subtotal – Reliability	349.07
Present Value of Benefits (PVB)	760.06
COSTS	
Total New Construction Cost with Contingency	343.61
Total Rehab Construction Cost with Contingency	111.92
Potential Mitigation with Contingency	18.90
Right of Way Cost	16.51
Solar Canopy Cost	30.29
Present Value of Costs (PVC)	521.24
OVERALL IMPACTS	
Net Present Value (NPV)	238.82
Benefit to Cost Ratio (BCR)*	1.5

**A BCR above 1.0 represents the anticipated benefits being greater than the anticipated costs*

Table 16-19c: Acceptable Fit Proposed Project Low Growth WebTAG Analysis of (Discounted) Monetised Costs and Benefits Including Solar Array, USD

Proposed Project Acceptable Fit Low Growth Monetised Costs and Benefits (USD 2024 $M)	
BENEFITS	
Noise	-44.39
Electric Cost Savings from Solar Canopy	81.85
Amenity Loss from Construction	-11.38
Total Emissions Benefits	-149.62
Subtotal - One-time Carbon Emissions from Construction	-26.04
Subtotal - Bulk Material Emissions	-32.67
Subtotal - Carbon Sequestration Impact	-5.12
Subtotal - Carbon Emissions from Traffic	-169.23
Subtotal - Carbon Emissions Savings from Solar Canopy	118.18
Subtotal – Non-carbon Emissions (NOx, SO2, VOC, PM2.5)	-34.75
Total Transportation Benefits	1,028.01
Subtotal - Economic Efficiency: Consumer Users (Commuting)	207.30
Subtotal - Economic Efficiency: Consumer Users (Other)	-52.96
Subtotal - Economic Efficiency: Business Users and Providers	457.78
Subtotal – Reliability	415.89
Present Value of Benefits (PVB)	904.47
COSTS	
Total New Construction Cost with Contingency	183.57
Total Rehabilitation Construction Cost with Contingency	33.68
Potential Mitigation with Contingency	22.49
Right of Way Cost	19.65
Solar Canopy Cost	36.04
Present Value of Costs	295.43
OVERALL IMPACTS	
Net Present Value (NPV)	609.04
Benefit to Cost Ratio (BCR)*	3.1

**A BCR above 1.0 represents the anticipated benefits being greater than the anticipated costs*

Table 16-19d: Acceptable Fit Proposed Project Low Growth WebTAG Analysis of (Discounted) Monetised Costs and Benefits Including Solar Array, CI$

Proposed Project Acceptable Fit Low Growth Monetised Costs and Benefits (CI 2024 $M)	
BENEFITS	
Noise	-37.30
Electric Cost Savings from Solar Canopy	68.79
Amenity Loss from Construction	-9.57
Total Emissions Benefits	-125.73
Subtotal - One-time Carbon Emissions from Construction	-21.88
Subtotal - Bulk Material Emissions	-27.43
Subtotal - Carbon Sequestration Impact	-4.3
Subtotal - Carbon Emissions from Traffic	-142.21
Subtotal - Carbon Emissions Savings from Solar Canopy	99.31
Subtotal – Non-carbon Emissions (NOx, SO2, VOC, PM2.5)	-29.20
Total Transportation Benefits	863.87
Subtotal - Economic Efficiency: Consumer Users (Commuting)	174.2
Subtotal - Economic Efficiency: Consumer Users (Other)	-44.5
Subtotal - Economic Efficiency: Business Users and Providers	384.69
Subtotal – Reliability	349.07
Present Value of Benefits (PVB)	760.06
COSTS	
Total New Construction Cost with Contingency	154.26
Total Rehabilitation Construction Cost with Contingency	28.30
Potential Mitigation with Contingency	18.90
Right of Way Cost	16.51
Solar Canopy Cost	30.29
Present Value of Costs (PVC)	248.26
OVERALL IMPACTS	
Net Present Value (NPV)	511.80
Benefit to Cost Ratio (BCR)*	3.1

**A BCR above 1.0 represents the anticipated benefits being greater than the anticipated costs*

Table 16-20a: Excellent Fit Proposed Project Medium Growth WebTAG Analysis of (Discounted) Monetised Costs and Benefits Including Solar Array, USD

Proposed Project Excellent Fit Medium Growth Monetised Costs and Benefits (USD 2024 $M)	
BENEFITS	
Noise	-44.01
Electric Cost Savings from Solar Canopy	81.86
Amenity Loss from Construction	-11.38
Total Emissions Benefits	112.69
Subtotal - One-time Carbon Emissions from Construction	-26.04
Subtotal - Bulk Material Emissions	-32.67
Subtotal - Carbon Sequestration Impact	-5.12
Subtotal - Carbon Emissions from Traffic	74.89
Subtotal - Carbon Emissions Savings from Solar Canopy	118.18
Subtotal - Non-carbon Emissions (NOx, SO2, VOC, PM2.5)	-16.55
Total Transportation Benefits	951.65
Subtotal - Economic Efficiency: Consumer Users (Commuting)	161.50
Subtotal - Economic Efficiency: Consumer Users (Other)	-19.09
Subtotal - Economic Efficiency: Business Users and Providers	404.25
Subtotal – Reliability	404.99
Present Value of Benefits (PVB)	1,090.80
COSTS	
Total New Construction Cost with Contingency	408.90
Total Rehab Construction Cost with Contingency	133.19
Potential Mitigation with Contingency	22.49
Right of Way Cost	19.65
Solar Canopy Cost	36.04
Present Value of Costs	620.27
OVERALL IMPACTS	
Net Present Value (NPV)	470.52
Benefit to Cost Ratio (BCR)*	1.8

**A BCR above 1.0 represents the anticipated benefits being greater than the anticipated costs*

Table 16-20b: Excellent Fit Proposed Project Medium Growth WebTAG Analysis of (Discounted) Monetised Costs and Benefits Including Solar Array, CI$

Proposed Project Excellent Fit Medium Growth Monetised Costs and Benefits (CI 2024 $M)	
BENEFITS	
Noise	36.99
Electric Cost Savings from Solar Canopy	68.78
Amenity Loss from Construction	-9.6
Total Emissions Benefits	94.70
Subtotal - One-time Carbon Emissions from Construction	-21.88
Subtotal - Bulk Material Emissions	-27.45
Subtotal - Carbon Sequestration Impact	-4.3
Subtotal - Carbon Emissions from Traffic	62.94
Subtotal - Carbon Emissions Savings from Solar Canopy	99.31
Subtotal - Non-carbon Emissions (NOx, SO2, VOC, PM2.5)	-13.91
Total Transportation Benefits	799.70
Subtotal - Economic Efficiency: Consumer Users (Commuting)	135.71
Subtotal - Economic Efficiency: Consumer Users (Other)	-16.04
Subtotal - Economic Efficiency: Business Users and Providers	339.71
Subtotal – Reliability	340.33
Present Value of Benefits (PVB)	916.64
COSTS	
Total New Construction Cost with Contingency	343.61
Total Rehab Construction Cost with Contingency	111.92
Potential Mitigation with Contingency	18.90
Right of Way Cost	16.51
Solar Canopy Cost	30.29
Present Value of Costs (PVC)	521.24
OVERALL IMPACTS	
Net Present Value (NPV)	395.40
Benefit to Cost Ratio (BCR)*	1.8

**A BCR above 1.0 represents the anticipated benefits being greater than the anticipated costs*

Table 16-20c: Acceptable Fit Proposed Project Medium Growth WebTAG Analysis of (Discounted) Monetised Costs and Benefits Including Solar Array, USD

Proposed Project Acceptable Fit Medium Growth Monetised Costs and Benefits (USD 2024 $M)	
BENEFITS	
Noise	-44.01
Electric Cost Savings from Solar Canopy	81.86
Amenity Loss from Construction	-11.38
Total Emissions Benefits	112.69
Subtotal - One-time Carbon Emissions from Construction	-26.04
Subtotal - Bulk Material Emissions	-32.67
Subtotal - Carbon Sequestration Impact	-5.12
Subtotal - Carbon Emissions from Traffic	74.89
Subtotal - Carbon Emissions Savings from Solar Canopy	118.18
Subtotal - Non-carbon Emissions (NOx, SO2, VOC, PM2.5)	-16.55
Total Transportation Benefits	951.65
Subtotal - Economic Efficiency: Consumer Users (Commuting)	161.50
Subtotal - Economic Efficiency: Consumer Users (Other)	-19.09
Subtotal - Economic Efficiency: Business Users and Providers	404.25
Subtotal – Reliability	404.99
Present Value of Benefits (PVB)	1,090.80
COSTS	
Total New Construction Cost with Contingency	183.57
Total Rehabilitation Construction Cost with Contingency	33.68
Potential Mitigation with Contingency	22.49
Right of Way Cost	19.65
Solar Canopy Cost	36.04
Present Value of Costs	295.43
OVERALL IMPACTS	
Net Present Value (NPV)	795.37
Benefit to Cost Ratio (BCR)*	3.7

**A BCR above 1.0 represents the anticipated benefits being greater than the anticipated costs*

Table 16-20d: Acceptable Fit Proposed Project Medium Growth WebTAG Analysis of (Discounted) Monetised Costs and Benefits Including Solar Array, CI$

Proposed Project Acceptable Fit Medium Growth Monetised Costs and Benefits (CI 2024 $M)	
BENEFITS	
Noise	36.99
Electric Cost Savings from Solar Canopy	68.78
Amenity Loss from Construction	-9.6
Total Emissions Benefits	94.70
Subtotal - One-time Carbon Emissions from Construction	-21.88
Subtotal - Bulk Material Emissions	-27.45
Subtotal - Carbon Sequestration Impact	-4.3
Subtotal - Carbon Emissions from Traffic	62.94
Subtotal - Carbon Emissions Savings from Solar Canopy	99.31
Subtotal - Non-carbon Emissions (NOx, SO2, VOC, PM2.5)	-13.91
Total Transportation Benefits	799.70
Subtotal - Economic Efficiency: Consumer Users (Commuting)	135.71
Subtotal - Economic Efficiency: Consumer Users (Other)	-16.04
Subtotal - Economic Efficiency: Business Users and Providers	339.71
Subtotal – Reliability	340.33
Present Value of Benefits (PVB)	916.64
COSTS	
Total New Construction Cost with Contingency	154.20
Total Rehabilitation Construction Cost with Contingency	28.30
Potential Mitigation with Contingency	18.90
Right of Way Cost	16.51
Solar Canopy Cost	30.28
Present Value of Costs (PVC)	248.26
OVERALL IMPACTS	
Net Present Value (NPV)	668.38
Benefit to Cost Ratio (BCR)*	3.7

**A BCR above 1.0 represents the anticipated benefits being greater than the anticipated costs*

16.3 Conclusion

Table 16-21 summarizes CBA results across growth scenarios and conceptual design options, using various discount rates to facilitate comparison of results.

Table 16-21: Proposed Project minus No-Build Including Solar Array CBA Results Summary (2024 $M)

Scenario	Discount Rate	NPV (Benefit – Cost) US 2024 $M	NPV (Benefit – Cost) CI 2024 $M	BCR*	IRR
Excellent Fit Low Growth	2%	638.86	536.86	1.9	3%
	WebTAG**	284.19	239.82	1.5	2%
	5%	-28.43	-23.89	0.9	0%
Excellent Fit Medium Growth	2%	911.41	765.89	2.2	3%
	WebTAG**	470.52	395.40	1.8	2%
	5%	45.48	38.22	1.1	0%
Acceptable Fit Low Growth	2%	1,018.94	856.26	3.8	6%
	WebTAG**	609.04	511.80	3.1	4%
	5%	248.69	208.98	2.1	3%
Acceptable Fit Medium Growth	2%	1,291.50	1,085.29	4.5	6%
	WebTAG**	795.37	668.38	3.7	5%
	5%	322.59	271.09	2.4	3%

**A BCR above 1.0 represents the anticipated benefits being greater than the anticipated costs*
*** 3.5% for years 1-30 and 3% for years 31-52*

- *Excellent Fit, Low Growth Scenario* – The project has a BCR ranging from 0.9 using a 5% discount rate to 1.9 using a 2% discount rate under the low population growth scenario. The BCR is greater than one, meaning benefits are greater than costs of the project, using the WebTAG discount schedule and a 2% discount rate. The BCR is just under one using a 5% discount rate, meaning costs and benefits of the project are close in value. Inclusion of the solar array contributes to these results.
- *Excellent Fit, Medium Growth Scenario* – The project has a BCR ranging from 1.1 using a 5% discount rate to 2.2 using a 2% discount rate under the medium population growth scenario. The BCR is greater than one for all three discount rates, meaning benefits are greater than costs. Inclusion of the solar array contributes to these results.

- *Acceptable Fit, Low Growth Scenario* – The project has a BCR ranging from 2.1 using a 5% discount rate to 3.8 using a 2% discount rate under the low population growth scenario. The BCR is greater than one, meaning benefits are greater than costs of the project, for all three discount rates. Inclusion of the solar array contributes to these results; however, BCRs remain greater than one without the solar array.
- *Acceptable Fit, Medium Growth Scenario* – The project has a BCR ranging from 2.4 using a 5% discount rate to 4.5 using a 2% discount rate under the medium population growth scenario. The BCR is greater than one for all three discount rates, meaning benefits are greater than costs. Inclusion of the solar array contributes to these results; however, BCRs remain greater than one without the solar array.

The results of the Excellent Fit CBA show that the low and medium population growth scenarios are expected to create a BCR above or near 1.0, which indicates that the anticipated benefits are greater than or close in value to anticipated costs.

The results of the Acceptable Fit CBA show that the low and medium population growth scenarios are expected to create a BCR above 1.0, which indicates that the anticipated benefits are greater in value to anticipated costs. Using the WebTAG discount schedule, anticipated benefits are more than three times greater than costs in the low and medium growth scenarios. Due to the Acceptable Fit having lower costs and equal benefits compared to the Excellent Fit, the BCRs are higher.

Peak travel scenarios were conservatively estimated to be only two hours in the AM and three hours in the PM, although weekday peak travel times have been noted to extend beyond these assumptions. The project may provide significant mobility and accessibility benefits and travel cost savings throughout the higher traffic midday and evening hours.

Additionally, there are a number of benefits which were qualitatively assessed and discussed in the previous ES chapters but not monetised as part of the Proposed Project CBA Evaluation due to available data, its level of detail, and its applicability at the time of assessment, such as safety benefits, public transportation benefits, pedestrian/bicycle amenities, and transportation system resiliency. For example, transportation infrastructure resiliency related to storms and flooding was discussed in Chapter 6: Proposed Project – Engineering Features whereas transportation network resiliency related to roadway closures and alternative routes was discussed in Chapter 7: Transportation and Mobility. However, there is currently no available data that quantifies the flooding or roadway closure frequency along the existing coastal roadway; and therefore, could not be monetised as part of the Proposed Project CBA Evaluation for neither the Excellent Fit nor the Acceptable Fit options.

The CBA results are based on conceptual design and may be refined within the detailed design phase of the project (outside of the EIA).

17 Concluding Remarks and Future Steps

17.1 Achievement of CSFs

The Proposed Project has been conceptually designed to meet the project objectives – Critical Success Factors (CSFs), while avoiding and minimising impacts to the project constraints (natural environment resources, social environment resources, and engineering constraints). Potential mitigation measures have been identified for unavoidable impacts to the natural or social environment, with further details to be included within the separate Environmental Management Plan (EMP).

A summary of the CSFs, their status and the degree to which the Proposed Project is expected to achieve them, are shown in **Table 17-1**. The degree of CSF achievement ranges on a scale of neutral, minor, moderate, and large, if applicable.

Table 17-1: Achievement of CSFs

Criteria	Target	Degree of CSF Achievement
a. **Alternate Routes:** Create an alternative travel route to the existing two-lane Bodden Town Road	Provide an alternative roadway facility to accommodate travel in the event of a roadway closure (**Section 6.1: Corridor Features and Timeline** and **Section 7.4.4: Resiliency**)	**Achieved -** Large Beneficial
b. **Existing Roadway Resiliency:** Improve resiliency of the existing roadway travel route between North Side/East End and George Town/West Bay.	Improve resiliency of the travel route to flooding from sea level rise, storm surge, wave overtopping, and rainfall (**Section 6.6.5 Vertical Grades, Cross Slopes, and Roadway Profiles** and **Section 7.4.4.2: Existing Coastal Roadway Resiliency**)	**Achieved -** Large Beneficial
c. **Future Traffic Demand:** Support current and future traffic demand.	Provide travel lanes necessary to accommodate projected trips/vehicles (**Section 7.4.3.2: Screenline Volumes** and **Section 7.4.3.3: District-to-District Work Trips**) Provide controlled access points to enter roadway facility (**Section 6.6.9: Intersections** and **Section 7.4.6: Intersection Delay**)	**Achieved -** Large Beneficial
d. **Commuter Travel Times:** Improve travel time between North Side/East End and George Town/West Bay	Improve projected travel time between North Side/East End and George Town/West Bay (**Section 7.4.5.1: Study Area Travel Time** and **Section 7.4.5.2: Travel Time to Key Destinations in George Town/West Bay**)	**Achieved -** Moderate / Large Beneficial
e. **Utilities:** Accommodate utility expansion (electricity, fibre, water, central sewage system) *	Establish area adjacent to roadway to provide for utility needs (**Section: 6.6.11 Utilities**)	**Achieved****
f. **Public Transit Access:** Provide opportunity to safely accommodate and expand public transportation *	Establish public transportation facilities and improve bus travel time reliability (**Section 6.6.8: Future Multimodal Facilities** and **Section 8.3.1.4 Option Value**)	**Achieved****

Criteria	Target	Degree of CSF Achievement
g. **Tourist Travel Times:** Reduce tourism travel time between North Side/East End and George Town	Reduce travel times between Owen Roberts International Airport and the North Side (**Section 7.4.5.2: Travel Time to Key Destinations in George Town/West Bay**) Reduce travel time between Grand Cayman Cruise Port (George Town Cruise Port) and Bodden Town/North Side/East End (**Section 7.4.5.3: Tourist Travel Times**)	**Achieved -** Large Beneficial
h. **Safety:** Improve safe vehicular travel by reducing roadway conflict points	Reduce the number of Cross Street Intersections along the primary east-west corridor (**Section 6.6.9: Intersections** and **Section 7.4.7: Safety**) Reduce the number of Driveway Access Points along the primary east-west corridor (**Section 6.6.9: Intersections** and **Section 7.4.7: Safety**)	**Achieved -** Large Beneficial
i. **Pedestrian and Bicycle Access:** Provide opportunity for enhanced and safe pedestrian and bicycle travel	Establish dedicated pedestrian and bicycle facilities adjacent to vehicular travel lanes (**Section 6.1.3: Will T Connector, Section 6.6.8: Future Multimodal Facilities** and **Section 7.4.8: Multimodal Access**)	**Achieved -** Large Beneficial

**These criteria are to provide opportunities to accommodate these features. It is outside the ambit of the NRA to provide utilities or public transportation.*

***Degree of achievement is not applicable*

17.2 ES Compliance

This document has been compiled as Step 5(ii) of the EIA Directive, Final ES. The Final ES was completed in compliance with the April 4, 2023, Terms of Reference for the EWA Extension, and input from the Project Steering Committee (**Section 1.5.4: Project Steering Committee**).

17.3 Future Steps

The outcomes of the Final ES will be used to develop an EMP [Step 5(iii)], which outlines the environmental monitoring and mitigation to be incorporated during project implementation. Based on the Final ES and EMP, the EAB will recommend to the NCC whether to approve or deny the application [Step 5(iv)]. The NCC then determines their recommendation to the NRA.

The steps above do not determine whether the Proposed Project will be implemented, but provide information for informed decision making. The decision (Step 6) of the EIA process is "*made by the Central Planning Authority, Development Control Board, or Cabinet or other authorizing entity; while taking into account the Council's [NCC's] recommendations*" (NCC, 2016).

In this case, the authorizing entity is Cabinet. After a decision is made by Cabinet, the NRA will carry out the project in accordance with the EMP (Step 7). Step 7 concludes the EIA process.

If the project is moved forward by the NRA, the next steps are to:

- Appropriate funding for detailed design and construction
- Inform detailed design with further data collection and analysis
- Complete detailed design of the corridor and mitigation commitments
- Acquire land/properties
- Relocate existing utilities where present
- Clear area for initial phase of the construction
- Construct project including mitigation commitments
- Open the project to traffic

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