


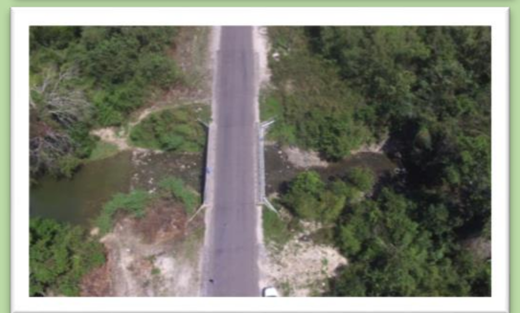


D-5 Report on the Environmental and Social Impact Assessments for the Rehabilitation of the Philip Goldson Highway between Miles 8.5 to 24.5

BELIZE Social Investment Fund

Since 1852 MOW

Ministry of Works

Belmopan, September 2017

BET

D-5 Report on the Environmental and Social Impact Assessment

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Cover: Juan R. Rancharan
Photo Credits: Top to Bottom: Rescued hawk fledgling; howler monkey, Black Creek; *Passiflora urbaniana* (Grampa Balls) endemic plant, Jones Lagoon area (J.R. Rancharan); Drone view of Mexico Creek Bridge and Drone view of Belize River, Grace Bank/Davis Bank (BET). Ladyville Flooding June 2017, Panoramic view of Jones Lagoon and Customary use of the waterways, Black Creek (J.R. Rancharan).

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Authors Note:

Measurements: the Metric System (SI) and the English System were used interchangeably for accuracy or ease of rounding off, especially when quoting a previous study. The same goes for the use of GPS UTM coordinates, NAD 27 or WGS84 DATUM (used by Google Earth) were used and indicated in the document.

Conversion Chart

Meters (m)	x	3.3 = feet
Meters (m)	x	1.1 = yards
Kilometres (km)	x	0.6 = miles
Square metres (m^2)	x	10.8 = square feet
Square metres (m^2)	x	1.2 = square yards
Acre (A)	x	43,560 = square feet
Hectare (ha)	x	2.47 Acres

ABBREVIATIONS

µs/cm	micro-Siemens per centimetre
AASHTO	American Association of State Highway and Transportation Officials
ACE	Accumulated Cyclone Energy
ACP	Africa Caribbean Pacific
AMSL	above mean sea level
BAAR	Belize Archaic Archaeological Reconnaissance Project
BATSUB	British Army Training Support Unit Belize
BCRIP	Belize Climate Resilient Infrastructure Project
BECOL	Belize Electric Company Limited
BET	Belize Environmental Technologies
BFD	Belize Fisheries Department
BMPs	Best Management Practices
BSIF	Belize Social Investment Fund
BTL	Belize Telemedia Limited
BWSL	Belize Water Services Limited
CAT (#)	Hurricane Category 1 to 5.
CBO	Community Based Organization
CCTV	Closed-Circuit Television
CITES	Convention on the International Trade in Endangered Species of Wild Flora and Fauna
CLOs	Community Liaison Officers
cm	centimetre
CO	Carbon Monoxide
CPS	Child Protection Services Division
CRFP	Community Relations Focal Point
CRIP	See BCRIP
CTWS	Crooked Trees Wildlife Sanctuary
dBA	A-weighted decibels are an expression of the relative loudness of sounds in air as perceived by the human ear.
DEM	Digital Elevation Model
DEMO	District Emergency Management Organization
DO	Dissolved Oxygen
DOE	Department of the Environment
DRA	Disaster Risk Assessment
DRM	Disaster Risk Management
ECP	Environmental Compliance Plan
EIA	Environmental Impact Assessment
ENSO	El Nino Southern Oscillation
EPA	Environmental Protection Act
EPP	Emergency Preparedness Plan
ESBA	Environmental Social Baseline Assessment

ESIA	Environmental Social Impact Assessment
ESMP	Environmental and Social Management Plan
EU	European Union
FD	Forestry Department
Fe	Iron
ft	feet
GBRB	Greater Belize River Basin
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Recovery and Reconstruction
GOB	Government of Belize
Golder	Golder Associates Ltd.
Ha	hectares
HAV	Hand-Arm Vibration
HDPE	High-Density Polyethylene
HEPS	Hurricane Emergency Plans
HH	households
Hurr.	hurricane
ICT	Information & Communication Technology
IDF curves	Intensity-Duration-Frequency curves
IDRM	Integrated Disaster Risk Management
IFC	International Finance Corporation (World Bank Group)
IPCC	Intergovernmental Panel on Climate Change
km	kilometres
KPIs	Key Performance Indicators
l	litre
LHS	Left Hand Side
LiDAR	Light Detection and Ranging Survey Method
LTHS	Ladyville Technical High School
M&E	Monitoring and Evaluation
m	metre
m^3	cubic metres
MCE	(participatory) multi-criteria evaluation
MCL	maximum contaminant level
mg	milligrams
MHD	Ministry of Human Development
mi	mile
MICS	Multiple Indicator Cluster Surveys
min	minute
mm	millimetre
MMBRB	Mopan-Macal-Belize River Basin
mmHg	millimetre of mercury (atmospheric pressure)
MNR	Ministry of Natural Resources

MNRA	Ministry of Natural Resources and Agriculture
MOH	Ministry of Health
MOW	Ministry of Works
MSL	mean sea level
NAD 27	North American Datum of 1927
NCD	Non-communicable diseases
NCIRP	National Climate Resilient Investment Plan
NDC	Nationally Determined Contribution
NEMO	National Emergency Management Organization
NGO	Non-Governmental Organization
NICH	National Institute of Culture and History
NIWRA	National Integrated Water Resources Authority
NO_3 - N	Nitrate–Nitrogen
NOAA	National Oceanic and Atmospheric Administration
NO_x	Oxides of Nitrogen
NPAS	National Protected Areas System
NTFPS	Non-timber forest products
NTU	Nephelometric Turbidity Units (Turbidity)
O&M	Operations & Maintenance
ONH	Old Northern Highway
ORP	Oxidizing Reducing Potential
PAPs	Project Affected Persons
PMU	Project Management Unit
PGH	Philip Goldson Highway
PMF	Probable Maximum Flood
PO_4	Phosphate
POI	Points of Interest
PPE	Personal Protection Equipment
ppm	parts per million
PPP	Public Participation Process
PPS	Probability Proportional to Size (Sampling Method)
ppt	parts per thousand
PRECIS	Providing REgional Climate for Impact Studies
PSWGIA	Philip S.W. Goldson International Airport
R.E.	Revised Edition (Laws of Belize)
RMP	Risk Management Plan
Ramsar	Convention on Wetlands of International Importance Especially as Waterfowl Habitat, 1971 (Ramsar)
RAP	Resettlement Action Plan
RC	Roman Catholic (schools) or reinforced concrete (culverts) (read in context)
Regs.	Regulations (Laws of Belize)

Rev. Ed.	See R.E.
RHS	right hand side
RMF	Road Maintenance Fund
ROW	Right of Way
RTA	Road Traffic Accidents
s	second
SAE	Small Area Estimation
SDA	Seventh Day Adventist
S.I.	Statutory Instrument
SES	Socio-Economic Survey
SIA	Social Impact Assessment
SIB	Statistical Institute of Belize
SIF	See BSIF
SMP	Social Management Plan
SO_2	Sulphur Dioxide
SO_4	Sulphate
SOP	Standard Operating Procedure
SO_x	Sulphur Oxides
SPC[ond]	conductivity
SPM	Summary for policymakers (read in context)
SPM	Suspended Particulate Matter (read in context)
SSB	Social Security Board
TC	Tropical Cyclone
TD	Tropical Depression
TDS	Total dissolved solids
TOR	Terms of Reference
TS	Tropical Storm
TSS	Total Suspended Solids
UIDN	Unique ID Number
UNESCO	United Nations Educational, Scientific and Cultural Organization
UTM	Universal Transverse Mercator
VOCs	Volatile Organic Compounds
VRs	Valued Receptors
WBV	Whole Body Vibration
WGS84	World Geodetic System 1984 used by Google Earth
WHO	World Health Organization
yds	yards

EXECUTIVE SUMMARY

Chapter 1: Project Description

The Government of Belize (GOB) developed a National Climate Resilient Investment Plan (NCRIP) and secured funding from the World Bank to address the impacts of climate change on social and economic development. The development objective of the Project is to enhance the resilience of critical road infrastructure against flood risk and impacts of climate change and to improve Belize's capacity to respond promptly and effectively in an "Eligible Crisis or Emergency", as required. The Philip Goldson Highway (PGH) from miles 8.5 to 24.5 has been identified by the Ministry of Works (MOW) as the first sub-project site under the Climate Resilient Infrastructure component.

The Philip Goldson Highway, formerly known as the Northern Highway, is critically important to the country's social and economic fabric, as it links Belize City the commercial and economic centre of Belize with the two northern towns of Orange Walk, the "Sugar Capital", and Corozal adjacent to the Corozal free Zone and Mexico's Southern Border.

The PGH is a two-lane, 92.1-mile highway, originally built in the early 1980s to upgrade the old Northern Highway, and was resealed approximately 13 years ago. Since then, the roadway´s pavement has deteriorated significantly, in particular between Ladyville (mile 8.5) and Gardenia Village (mile 24.5), due to: (i) insufficient/poor drainage; (ii) the sharp increase in truck and bus traffic transporting workers and commerce in and out of Belize City, and to a lesser extent, the agriculture and tourism sectors; and (iii) limited maintenance. The pavement's poor conditions together with the absence of paved shoulders, unsafe road alignments, lack of pedestrian facilities in urban areas, and limited marking and signage add to Belize´s high incidence of road fatalities.

The areas serviced by this section of the highway are critical to the country's agricultural sector as it is a major artery for the delivery of agricultural produce from some of the country's most important agricultural lands. It also services the economically important tourism sector in the area and provides the link to many important tourism destinations such as Altun Ha, Lamanai, Crooked Tree Wildlife Sanctuary, and the Bermudan Landing Baboon Sanctuary.

Of equal importance is the fact that this section of the highway is a part of the Pan American Highway, linking the rest of Central America with Belize. As an international highway then, the Philip Goldson Highway, including this section, must be constructed to international standards. The rehabilitation of this section of the PGH is proposed to be done in accordance with AASHTO standards.

The Belize National Evacuation Plan identifies these issues associated with the PGH as critical and in need of urgent attention. It recommends that roads be constructed in such a way as to ensure that they will remain open in order to allow threatened populations to be evacuated. Alternate roads should be constructed or upgraded in cases of loss of the primary evacuation route and that projected peak evacuation traffic loads should be factored into road designs.

The Study Area

This 16 mile segment of the Philip Goldson Highway Study Area is partitioned into 2 sections for the purposes of this ESIA, as follows:

(i) **Section 1:** Vista del Mar Junction re-design and 200m East of Airport Junction in Ladyville at mile 8.5 to Burrell Boom Junction at mile 14; This section is further divided into two subsections: 1A Vista del Mar Boulevard Junction to Lords Bank Junction and 1B subsection from Lords Bank Junction to the Burrell Boom Junction.

(ii) **Section 2:** Boom Junction to mile 24.5, PGH near Gardenia Village. This section is also divided into two subsections: Subsection 2A from Burrell Boom Junction to Old Northern Highway Junction in Sandhill and subsection 2 B from the Sandhill Junction to mile 24.5 in Biscayne. Section 1 of the project area passes through what can be considered as an urbanized area while Section 2 passes through more a rural setting.

The proposed rehabilitation section (miles 8.5 – 24.5) of the PGH traverses the lower sub-catchment of the Belize River watershed; a characteristically flood-prone region of the Belize District. The study area is defined as a band four kilometres east and four kilometres west of the centre line of the current road which includes the villages of Ladyville, Lord's Bank, Sandhill, Gardenia, and one and a half miles into Biscayne.

The micro-catchments in the zone are: Mexico Creek, Mussel Creek, and Black Creek. The vulnerability of this section of the highway was very evident during recent extreme weather events (TD 16, 2008; Hurricane Keith 2000); resulting in failing pavement, bridge infrastructural damage, and traffic disruption.

The sections of the highway most vulnerable to floods are the Ladyville area, and the section around Mexico Creek Bridge which has been submerged with half-a-foot to one foot of floodwater for about half-a-mile distance on two or more occasions during the past ten years; while high-energy flood waters through Mexico Creek have strained the Mexico Creek Bridge infrastructure.

Further up at Gardenia Village, the highway runs through a floodplain, with wetlands or 'bajos' on either side. The Village is often affected by flood water from nearby Mexico Creek, making life during these periods unbearable for residence, coupled with water-borne pests and diseases.

Portions of the highway are also submerged by one-foot or more of flood water in some sections during intense weather events. Extended sections of major roads and feeder roads connecting to the PGH were inundated during the TD-16 2008 floods, and communities were only accessible by boats. For example, the Grace Bank and Davis Bank entrance, near the Mexico Creek Bridge, has high energy water flowing parallel to the highway, cutting off villagers from these communities

Expected Project Outputs

The Project has four main outputs that are expected to address several critical issues as outlined below:

i) Existing Pavement and Drainage Rehabilitation of Miles 8.5 – 24.5 of the PGH between Ladyville and Gardenia/ Biscayne (one and a half miles into Biscayne Village);

ii) Construction of a link canal from PGH to Vista Del Mar Canal to reduce the duration and extent of flooding in Ladyville;

iii) Restoring original cross section of Mexico Creek, and cleaning of Mussel Creek and Black Creek to improve hydraulic efficiency and reduce the incidence of flooding of surrounding villages; and

iv) Mitigating the flooding of Mexico Creek and other susceptible areas along the route of the Project.

Chapter 2: Road and Infrastructure Conditions

This chapter provided information synthesized from the various assessments (road pavement, culvert, bridge and traffic) conducted by the MOW and Belize Environmental Technologies (BET) key personnel in preparation for the anticipated Rehabilitation of miles 8.5 – 24.5 (km 13.6 – 39.2) of the PGH between Ladyville and Gardenia /Biscayne Villages.

General Road Conditions

The entire project road section road base and sub-base was stabilized and layered with a flexible type of pavement which was finished with a double surface dressing to the pavement surface.

The section of road between the Vista del Mar Junction and the airport road junction at mile 8.5 was recently resurfaced in early 2017. The width of the pavement in this section including the paved shoulders is approximately 34 feet. Noted is the absence of safety features for pedestrians and cyclists which are to be provided, especially in urban areas.

The section of road from the airport junction at mile 8.6 up to Gardenia/Biscayne Villages at mile 24.5 was last resurfaced approximately 15 years ago. The resurfacing was a single surface dressing made to stop the stripping of the aggregates from the paved surface.

The condition of the road surface ranges from fair to poor over different sections of the road. The pavement surface with the poor condition is located between the Lake Garden Community junction at mile 11.25 and Los Lagos Community at mile 13.5. The field reconnaissance revealed the absence of guardrails in highway sections that had steep embankments. These highway sections are to be identified and guardrails provided with impact attenuators. The remaining sections have a running surface that is in fair conditions.

Road super-elevation is minimal and has contributed to accidents by speeding vehicles. The carriageway width is not uniform in this section of the road, which has been caused by the gradual breaking of the pavement edge. The road shoulders are not paved. Paved surface and shoulders have differences in level of up to 4 inches. Trees growing along certain sections of the roadside do not allow for good visibility and their removal will need to be considered. Road signs are lacking or in need of maintenance for pedestrian crossings, speed bumps, speed limits, school zones and speed limits, destination, warning and informative signs. Urban areas are to be provided with safety features for pedestrians and cyclists.

Drainage

The entire project area is located within what is classified as the northern plains. The study area containing the PGH lies within a landscape dominated by lowland savannah wetlands and associated lagoons, streams and a section of the Belize River. The highway itself acts as a dam, disrupting the natural drainage of the area, a situation that has probably contributed to the current intermittent flooding affecting communities along the PGH. The hydrological study is to provide a solution for the flooding and damming effect.

The longitudinal side drains are filled with wetland vegetation that strives in stagnant water particularly the section of the highway that passes through the Ladyville Village. The water table in the height of the dry season in the month of April was measured to be approximately 22 inches below the pavement edge. The water flow in this area is very limited and has been exacerbated by the land filling activities associated with land development that has increased in the recent years with minimal consideration for proper drainage.

Development over time by property owners along the highway has reduced the wetland areas that stored excessive storm water. Also, there has been an increase of intense rainfall in the project area.

In the Lord's Bank junction area leading up to the junction with the old Northern Highway there are no defined longitudinal side drains which might have been silted up over time and overgrown with vegetation. The pavement structure in this area was just built higher than the natural surrounding area and culverts were installed to connect water bodies. In the section of road from the junction of the old Northern Highway with the Philip Goldson Highway up to the Gardenia/Biscayne Villages (mile 24.5), the longitudinal side drains have silted up and are overgrown with vegetation. Accesses to private property have been constructed with and without culverts. In addition, several of the culverts are either too small or partially blocked. Water logged areas are being filled up to make provision for development. There is limited provision for channelling water away from the pavement structure. Private developers have in some instances provided longitudinal drains parallel to the PGH but these again have no definite channelization for the removal of the water away from the pavement structure.

Mexico Creek Bridge Conditions

The Mexico Creek Bridge structure is a two-lane bridge with shoulders and two sidewalks. The bridge is composite structure consisting of reinforced concrete deck and steel beams. The sidewalks are 2 feet and 6 inches wide with handrails. The bridge provides support for the Belize Water Services Limited (BWSL) potable water main on the western side of the structure.

The bridge is considered to be in good structural condition with minor maintenance requirements identified. The maintenance could be in the form of painting to the structural beams to prevent corrosion, the cleaning of the deck drainage to avoid the accumulation of water on the deck surface, repair/painting to damaged handrails, and the cleaning of the waterway to allow for the flow of water under the bridge.

The provision of proper signage to indicate the bridge approach and location are outstanding. In addition, a structural evaluation of the Mexico Creek Bridge is recommended with due consideration to the bridge load requirements of the Ministry of Works since the movements created by vehicular traffic seems to be on the high side (MOW personal communication).

Material that was used either for the temporary bypass or as coffer dams while the bridge was being constructed, was not properly extracted, and now restricts the proper flow of the Mexico Creek affecting the proper draining of the Jones and Mexico Lagoons during the dry season. An assessment of the bridge foundation is recommended to determine whether the imported material on the stream bed can be removed or not without causing any adverse effects such as scouring to the bridge sub-structure proper or the bridge approach.

Culverts

Thirty-six culverts were identified by BET during the field reconnaissance for which the coordinates, material type, and size of culvert are provided. Eleven culverts were identified in Section 1 and twenty-five in Section 2. Many of the culverts were either almost completely blocked or partially blocked and several appeared to be too small.

Of note is the continued use of High-Density Polyethylene (HDPE) and Armco (corrugated galvanized steel) culverts along the project route. Reinforced concrete cylindrical culverts have also been used to replace damaged culverts. It should be noted that the MOW requires that reinforced concrete cylindrical or box culverts be used in the construction of any major highway. A 36-inch minimum diameter is recommended for the cylindrical culverts.

The Armco type culverts have a tendency to corrode at the water fluctuation level area. Welded steel drums culverts encased in concrete were also used as stay in place formwork, which has corroded. The HDPE culverts were observed to deflect or deform under the vehicular loads leading to the deformation of the pavement structure. Recommendation is made for RC culverts either cylindrical or box type be used since these have a longer service life and can be designed to carry expected vehicular loads safely without affecting the pavement structure. The RC culverts are not a fire hazard when compared to HDPE culvert which is a petroleum-based plastic that is combustible and which has been used to replace ARMCO type culverts along the project section.

Traffic Flows

The free flow of traffic on the PGH project section is affected by several problems including the absence of pedestrian facilities such as designated bus stops; all weather shoulders for the movement of pedestrians and cyclists; the temporary parking of vehicles on the carriageway causing the queuing of traffic particularly in peak hours; the frequent turning of vehicles caused by the turning of vehicles on to several accesses/side roads that have direct access to the PGH; the frequency of junctions without merging lanes; and the lack of signage and line markings.

Historical records of traffic counts carried out by the Ministry of Works were obtained from the MOW and the Airport Link Highway Corridor Study of June 2000 prepared by BECA International Consultants reported on the location of traffic census points, the description of the traffic census location points, and the traffic census data for the years 1971 – 1995, respectively.

Traffic census and axle load surveys were conducted under the Feasibility Study to complement the historical data. It was expected that since 1992, traffic flow on this Section of the highway has increased significantly. This was corroborated by the results of the analysis reported and prepared for Golder Associates Ltd. (Golder) by Anthony Thurton & Associates Ltd. (Automatic Traffic Count Report, 2017).

The report identifies three stations where the automatic traffic counts were carried out. The stations that are comparable to the historical data are as follows:

- **Station 1** which provides a combined 7-day traffic volume of 3810 which could be compared with traffic census point # 2 of the MOW`s traffic census map which in 1995 had a combined traffic volume of 3455. The difference in the traffic volume is an increase of 355.
- **Station 3** which provides a combined 7-day traffic volume of 3574 which could be compared with traffic census point # 2 of the MOW`s traffic census map which in 1995 had a combined traffic volume of 1083. The difference in the traffic volume is an increase of 2491.

The above serves to indicate; a) a traffic volume increase at both points and b) that the local traffic volume increase is small in comparison to the traffic volume to and from the northern districts.

Road Safety

Belize roads and highways have continually experienced a high incidence of fatal traffic accidents. According to a World Bank Report (2003), lack of investment in road safety such as adequate driver's training and testing, road layout and design, vehicle conditions, police, and judicial enforcement of traffic laws, and human behaviour are also major contributors to road traffic injuries.

Analysis of the data from 2001-2005 revealed that 35% of all deaths as a result of road traffic injuries occurred in the Belize District. However, there are several explanations to this. Firstly, the Belize District has one third of the country's population, and therefore has the highest number of vehicles per family.

In 2011, there were 6 fatal traffic accidents and 7 deaths reported within the Project Area between miles 12 and mile 21. In addition in 2012 there were 6 fatal traffic accidents and 6 deaths reported within the project area.

The Road Safety Project Office reported that of the 57 fatalities between 2014 and 2016, at least 15 were the result of fatal crashes within the study area (based on news reports). The approximate location is available for 9 of them. In addition, 3 were reported to by Ladyville Police (and therefore likely occurred in or around the Ladyville area). The locations of the other four crashes were unspecified.

Most accidents happen on major highways, and involve private vehicles. This has become a frequent occurrence as more Belizeans are moving outside the major cities and towns, and therefore commute on a daily basis.

The PGH Project route currently has no pavement markings which is a basic requirement to reduce traffic accidents. Delineation treatments, including pavement markings, help drivers track the roadway alignment and keep their vehicles within their assigned lanes; centreline markings also identify where passing manoeuvres are, and are not, appropriate on two-lane undivided highways.

Countermeasures proposed by a 2012 International Road Assessment Programme (iRAP) Belize Final Technical Report for making Belize's roads safer include shoulder widening, roadside safety barriers, delineation, pedestrian crossings, traffic calming, road surface upgrades, pedestrian footpath, signalized intersection, delineated intersection, road side safety hazard removal, bicycle facilities, and lane widening.

Chapter 3: Policy and Legal Framework

The Policy and Legal Framework in which the rehabilitation of the PGH will take place is made up of national advisory policies which seek to ensure that the activities of the proposed road project are aligned with GOB's national sustainable development goals; a few important MEAs and Belize's environmental and socio-economic laws which protect the environment and the socio-economic well-being of persons who may be affected by the road rehabilitation; and the environmental and social framework of the World Bank which commits the World Bank to sustainable development through its Investment Project Financing, by a Bank Policy and a set of Environmental and Social Standards that are designed to support MOW/GOB's rehabilitation of miles 8.5 to 24.5 of the PGH, with the aim of ending extreme poverty and promoting shared prosperity.

Chapter 4: Environmental Settings

This chapter provides the baseline information of the Study Area and includes additional background environmental information collected by the ESIA team from the various rapid assessments that included the following:

- a rapid survey of the flora and fauna of the project area with special emphasis on these wetlands system and creeks within the study area.
- a geological assessment of the area,
- hydrological and water quality assessments of the Mexico Creek, Mussel Creek, Black Creek and Jones Lagoon, inclusive of sections of the Belize River
- a rapid assessment of the environmental quality of the project area as it relates to air quality and noise.

The information is presented by providing a general background of the Lower Belize River Basin Area, then narrowing the information to the general study area and finally focussing on the two project sections.

Also included in this chapter is information of the highway's vulnerability to natural and manmade disasters and to that of climate change.

Chapter 5: Socio-Economic Settings

This Chapter of the Environmental and Social Setting Section provides a description of the existing social environment and is underpinned by an analysis of key demographic characteristics, social infrastructure, social values, and lifestyles using established indicators. The baseline provides the platform from which to identify any social impacts the community may face, or changes that may occur to the existing social environment, by the introduction of the proposed Road Rehabilitation Project; and enables the identification of effective strategies to help mitigate the negative impacts associated with the Project, while maximizing the positive impacts associated with the Project.

The Social Baseline component of the ESIA Study utilized a mixed method approach and relied on the use of primary data derived from a carefully targeted survey and right-of-way census and complemented by key informant interviews, focus group discussions and direct field observations over the period March-April, 2017. Additionally, these primary data sources were further complemented by secondary data derived from the 2010 Census and relevant literature review of the Study Area comprising the villages.

This Chapter also addresses social issues related to Cultural Heritage in accordance with the National Institute of Culture and History Act Chapter 331 where a complete archaeological assessment was conducted within the Study Area. The archaeological assessment indicated that there were no archaeological remains of significance within the immediate vicinity of the road and its ROW.

Included also is information on involuntary resettlement which is in tandem with the specified objectives of the World Bank Policy on Involuntary Resettlement, Operational Policy 4.12, i.e. to avoid or minimize involuntary resettlement; to make any resettlement activities a sustainable development program, including through project benefit-sharing and meaningful consultation of affected persons; and to assist displaced persons in their efforts to improve, or at least restore, livelihoods and living standards (WB, 2001). The Policy extends assistance to people who do not own property but are nonetheless affected by development projects, including groups with communal and/or traditional tenure arrangements, renters, wage-earners and those without legally recognized rights to land and property that they occupy or use.

A Resettlement Action Plan shall be prepared which would seek to reduce the amount of resulting land expropriation and resettlement related to the proposed road rehabilitation project and ensuring reasonable compensation and assistance be provided to the population affected by construction works, so that their original production capacity, income level and living standard can be maintained or improved upon.

Chapter 6: Assessment of Environmental and Social Impacts

This Chapter of the ESIA presents the assessment of the potential environmental and social impacts associated with the proposed road rehabilitation project. For each relevant environmental and social parameter, the potential impacts are discussed. The evaluation of potential environmental and social effects during the ESIA aims to be as accurate and objective as possible, whilst providing as much detail as is available according to the proposed design. Many of the potential impacts have also been taken into account during design of the project through iterative discussions with the design engineers and MOW.

The information is presented into two main sections:

1. The first main section examines all the Environment Issues. It assesses the potential impacts associated with the various thematic areas and provides recommended mitigation measures. This section is subdivided into five subsections;

i. Impacts Related to Geology which examines issues related to Tectonics and Seismicity and a rapid evaluation of the geological risks with this section of the PGH. It assesses the issues related to materials requirements and extractions and provides recommended mitigation measures to address theses and earth moving activities related to the road rehabilitation activities.
ii. Impacts to Hydrology which examines the issues related to drainage and flooding within the project area since several sections of the highway are prone to flooding from storm surge, inundation from heavy torrential rainfall and extreme flooding events within the Belize River. This sub-section provides information on the results of hydraulic modelling conducted by Golder and provides a series of proposed mitigation measures to address the highway's vulnerability to flooding and to improve drainage.
iii. Environmental issues related to pollution impacts and addresses water quality, solid waste disposal, noise, vibration, and air pollution and provide a series of recommended mitigation measures aimed at addressing these issues.
iv. The fourth subsection of information assesses the issues related to DRM and Climate Change
v. The fifth subsection looks at the impacts to the areas ecosystems and biodiversity.

2. The second main section of information examines the issues related to the potential Social Impacts. The social impact assessment is designed to ensure that the Project's potential impacts on individuals and groups of people are understood, so that positive impacts can be enhanced by Project design while negative ones are mitigated, without compromising the economic efficiency of the MOW Road Project and its benefits for project affected persons (PAPs). Ideally, this should be achieved without negative impacts.

   The social impact assessment indicates that in both construction and operational phases of the Project, there is an opportunity for maximizing positive impacts on local employment through involving unskilled (and where possible skilled) labour from all Project communities. However, although the generation of employment opportunities resulting from Project activities are expected as a positive impact, there is a risk that conflicts could arise between local residents and new comers or outsiders over such employment opportunities. Furthermore, there is high risk that, unless Project employment and contractors are managed appropriately, the recruitment procedure could be less than transparent, meaning that people without connections would not get access to Project opportunities – namely employment and other livelihood benefits

Summary of Environmental and Social Impacts

While the proposed rehabilitation project is projected to have significant positive social and economic benefits it has the potential to affect the surrounding air and water quality; exacerbate soil erosion and soil stability, and the hydrology and drainage of the area as well. The impacts to the wetlands ecosystems and wildlife within the project area is reduced by the fact that the project entails the rehabilitation of an existing highway with the potential to improve connectivity through improved culverts and drainage allowing for improved flow of water across the highway. In addition, to these environmental issues, the activities of the proposed road rehabilitation activities will temporarily, negatively impact the lives of residents of communities along the ROW and road users. In the areas requiring horizontal alignments outside the road right of way and junctions for proposed runabouts, there will be the need for the acquisition of small strips of private properties. The potential social impacts are discussed in the section pertaining to social impacts. It is expected that at the end of the road rehabilitation project there will be significant net positive social and economic benefits and an improved quality of life for residents of the study area and the remaining Belizean populace. The assessment provides abatement measures that are tailored to reduce these potential adverse impacts to the point where the impacts are insignificant or within acceptable limits, either through effective design and best practices or through sound Environmental Management System (EMS) of the road rehabilitation activities.

Most of the impacts are predicted as either minimal to medium, are very localized and of short duration. The activities with the highest impacts are those associated with the concept of the link canal, construction of new bridge followed closely by road alignment and earthmoving activities requiring that close attention be placed on these main activities especially when occurring within the identified critical areas identified. It is recommended that the proposed link canal be looked at more closely prior to implementation

Chapter 7: Assessment of Alternatives

As part of the EIA requirement, there is the need to assess alternatives to a proposed development and its associated activities. There are usually two or more important alternatives for each major proposed activity to be considered. The evaluation of alternatives may encompass a wide range of economic, social, and environmental considerations associated with the various available options.

This section focuses on the evaluation of the major alternatives to the proposed rehabilitation of Mile 8.5 to 24.5 of the Philip Goldson Highway, inclusive of the 'No Action Alternative'. The discussions focus on the options that are most practical for the proposed Study Area.

The primary alternatives considered included the examination of a minimum of three main alternatives for the rehabilitation of the Philip Goldson Highway, viz. the "no action' alternative and two other potential technical options for the following critical issues identified:

a) Road Design Speed in consideration of road safety issues and the passage of the highway though rural and urban Area;
b) Vulnerability of road section to flooding from heavy rainfall, backflow of Belize River and storm- surge and projected Climate Chang Impacts and existing poor drainage conditions;
c) Road Surfacing consideration to improve road resiliency in addressing present and projected climatic conditions;
d) Need for improved Highway access at points of intersections along this section of highway.

The **'No Action Alternative'** although discussed and required to be considered, often represents an option in these types of projects, that is not always the least impacting and in the best interest of the general public, or proponent, from an environmental, economic and social point of view. In these instances, both the proponent (MOW) and regulatory agency need to consider the economic and social opportunities a project of this nature presents in addressing outstanding issues and the future development of the area.

A. Assessment of Design Speeds Alternatives

The options with respect to speed design looked at the following:

i) Option I: an AASHTO standards two-lane undivided highway with paved shoulders accommodating a design speed of 100 km per hour in rural settings and 40 km per hour two lane highway in urban areas between Lords Bank and Ladyville to be considered as the Technical and Feasibility **TOR Design Speed option**;

ii) An AASHTO standards for a two-lane undivided highway with paved shoulders accommodating a design speed of 100 km per hour in most rural settings but which remains within the existing highway ROW and considers the minor smoothing out of curves and the use of speed reducing measures to address road safety issues in identified sharp curves and a 40 km per hour four-lane highway in urban areas between Lords Bank and Ladyville as a possible **Variable Design Speed option.**

Option I would require significant horizontal alignment and accompanying significant land acquisition cost. The social impacts from the required horizontal alignments would be relatively high and primarily associated with shifting property values, loss of highway services in areas of realignment, temporary disruption, and disturbances caused by road construction activities. The social implications associated with the acquisition of private properties and the loss of access to highway services by existing homes along areas of alignments in would be relatively high. In addition, the construction of these new sections of road alignments would require much larger volumes of sub-base and base material with their increase accompanying environmental impacts.

In addition, the two-lane highway in the urban area between Lords Bank and Ladyville would not adequately address the traffic congestion that occurs in this area during peak traffic hours in the morning and evening from daily commuters.

Option II is almost similar to option I only that it confines all road alignments and other road rehabilitation activities to the existing highway right of way and would only address issues of encroachment within the existing ROW to accommodate the proposed road rehabilitation activities. In this option a design speed of 100 Km per hour is maintained for most rural areas with some reduced speed when passing through communities or to address road safety issues at a few curves located at miles 16, 17 and 18.

In section 2a reduced speed zones through settlement areas having design speeds of 60 km/h (35 mph) is recommended; this section of the highway is recommended as an undivided 2 lane highway including 2 bicycle fully paved shoulders. For the Section between Sandhill to Mile 24.5, a design speed of 100Km per hour is recommended with a 2-lane undivided highway having 2.5 m wide shoulders of which 1 meter would be paved.

This variability in design speeds takes into consideration the passage of the highway though rural communities and an urban setting, which exists in the Lords Bank and Ladyville area with speed limits of

40 km per hour, making provisions to address community needs, projected traffic use, and traffic safety issues.

The potential impacts to the environment and resources of the area are for the most part readily mitigated, while offering an opportunity for significant benefits to be derived from the implementation of the proposed activities.
This option would reduce significantly the social implications associated with the proposed highway rehabilitation project and the cost associated with land acquisition and would also have the least environmental impacts. As such, this would be the least costly and with the least negative environmental and social impacts of all three technical options. **This option has been recommended as the preferred option.**

B. Alternative for Points of Intersections

Along this sixteen-mile section of highway, there are several important points of intersection that would need to be considered in the highway rehabilitation to allow for safe access and egress to highway. Some of these points of intersection have been identified as potential bottlenecks and high-risk sites for accidents.

The project is recommending that three major intersections have roundabouts, matching recent major intersections constructed on the Western Highway. These roundabouts will provide continuous flow (which will avoid illegal movements to avoid queues) and accomplish speed control for passage of pedestrians.

Minor side roads are recommended to consider either a left turn lane or a right-side bypass lane. The preference is for the right-side bypass lane to avoid collisions as drivers locally may not respect the left turn lane markings (or they may not be maintained). The right-side bypass lane will operate even if lane markings are not maintained.

Also recommended were pavement markings: centreline striping (to define passing opportunities/no passing zones; right lane edge striping on curves; and right lane striping where full or partial pavement is used on shoulders or there are bike lanes.

C. Belize River Flood Alleviation Considerations

The assessment of these alternatives are based on the field analysis, hydraulic modelling conducted by Golder submitted the updated flood mitigation options for the PGH based on the list of criteria and the final road designs.

Dredging of the Haulover Creek and excavation of the proposed 12.5 km canal between Mexico Creek and the coast

Preliminary assessment of dredging of the Haulover Creek as a measure for flood alleviation on the PGH showed that it would have little impact to reduce Belize River water levels. This Option was therefore not considered in subsequent analysis and deliberations.

Proposed flood adaptation and mitigation options

Option 0: Raise the Road to 25-year flood level
Raising the PGH crest to an elevation above the calculated Belize River flood levels in consideration of the proposed criteria for the road design. This is the base option. This Option would require that approximately 1,700 road lengths be raised by an average of 0.9 m, which includes 0.5 m freeboard between the proposed road crest and the calculated flood water level. Estimated cost is approximately $2.7 M USD.

Option 1: Large Vista del Mar Channel between the Belize River and Vista del Mar marina
Excavate a channel between the Belize River and Vista del Mar marina roughly following the alignment of existing Vista del Mar drainage channel.

Excavate a 30-m wide (at the base), 3H:1V side slopes, 6 m deep (at Belize River) channel, approximately 950 m long channel between the Belize River and the Vista del Mar marina is projected to decrease flood water levels along PGH up to 0.4 m.

Option 2: Vista del Mar Channel between the Belize River and the Vista del Mar marina
Excavate a channel between the Belize River and Vista del Mar marina roughly following the alignment of existing Vista del Mar drainage channel.

Excavate a 5-m wide (at the base), 3H:1V side slopes, 2 m deep (at Belize River) channel, approximately 950 m long between the Belize River and the Vista del Mar. marina. It is projected that this would decrease the water level along the PGH by only 0.06 m.

Option 3: Connecting the Belize River to Two Existing Clover Leaf Canals South of the Vista del Mar Road Junction
Excavate channel connecting the Belize River with two existing drainage canals called the Clover Leaf canals, which extend between the coast and close to the PGH about 800 m south of Vista del Mar road junction. Channels need to be extended about 100 m to connect to the Belize River. The extension will be via a 24.4 m wide channel, 1H:1V side slope, 4.5 m deep to match the combined dimensions of the two exiting Clover Leaf canals. Additional excavation will be required at canal outlets on the coast. This measure would decrease the flood water levels along the PGH by 0.25

Option 4: Enlarge the Existing Clover Leaf Canals and Connect them to the Belize River
Enlarge the two existing Clover Leaf canals to a total width of 30 m (15 m each), and change to vertical slopes by installing sheet piles or similar structural measures. Deepen canals to achieve a depth of about 4.5 to 5.0 m from Belize River to the coast.
This measure would decrease the flood water levels along the PGH by up to 0.38 m.

This assessment would indicate option 4 as the preferred option. However, all conceptual channel options proposed for flood alleviation are designed to connect the Belize River to the coast, and involve major engineering works with significant environmental and social impacts, and high costs. The recommendation is to conduct further hydraulics and feasibility studies, and detail investigation on the impacts of these flood mitigation measures on the coastal ecosystem and wetlands. This would need further careful consideration to inform the choice of the best flood mitigation option for the Mile 8.5 to 24.5 segment of the PGH

D. Road Surfacing Alternatives

The assessment of baseline information indicated that almost the entire length of the PGH would need to be resurfaced with the exception of approximately 0.4 miles from the Vista Del Mar Junction to the Philip Goldson International junction, which was recently resurfaced and appears to be in good condition. The evaluation for road surfacing looked at the following four alternatives: a flexible chip seal surfacing; using a semi-structural flexible hot mix asphalt road surfacing; using a rigid concrete surfacing and the no action alternative. Noise reducing pavements were also examined because of their ability to reduce noise by five or more decibel levels. In the USA these pavements or specialized asphalt mix were estimated as 25% costlier than the normal hot mix. Hence, because of their local unavailability, local application knowledge and their cost are not further examined as potential alternative.

Based on the assessment a double-chip seal would be the recommended option with sections that are vulnerable to flooding and storm surge impacts considering concrete to make these sections more robust.

Chapter 8: Environmental Liabilities

The environmental liabilities evaluated in this section are those that are derived from the impacts identified in the Impact Assessment portion of this report. These impacts were assessed based on the social, ecological, and physical information collected during the Environmental and Social Baseline Assessment (ESBA).

As, such, the environmental liabilities that could arise as a result of the construction activities required for the rehabilitation of the PGH from miles 8.5 to 24.5 are *potential* in nature. **These *potential* environmental liabilities depend on certain activities occurring in the future for them to become operative; but they can be prevented from occurring as the Contractors/MOW/GOB have the opportunity to alter or adopt new practices to avoid or reduce adverse environmental impacts.** For this evaluation, these *potential* environmental liabilities are confined to the impacts that put at risk the route and its users; and impacts that put at risk the areas, ecosystems and communities near the right-of-ways; accesses and ancillary facilities during construction of the PGH and the impacts of natural hazards on the successful realization of the road restoration and operation. In other words, the environmental liabilities assessed in this section are those that arise from the assessed impacts as a result of how the road is constructed and which affect third parties who use the road, and those that arise from the assessed impacts on third parties as a result of the existence and use of the road; and are liabilities for which someone may be held legally responsible for.

The environmental liabilities evaluated are therefore classified as: Geological/Earthworks Liabilities, Hydrological/Water Pollution Liabilities, Air Pollution Liabilities, Noise Pollution Liabilities, Vibration Liabilities, Construction Related Man-Made Hazards Liabilities, Natural Resources and Environmental Services Liabilities, Cultural Heritage Liabilities, Injury and Accidental Health Damage Liabilities, Involuntary Displacement Liabilities, and Livelihoods Destruction Liabilities.

Chapter 9: Environmental And Social Management Plan

Chapter 9 focuses on the development of a social and environmental management plan to reduce potential adverse impacts to the point where the impacts are insignificant or negligible; either through effective design, the use of green technologies and best practices, or through sound operational management of the Road Rehabilitation Project and its accompanying activities. The management plan proposed for the rehabilitation of the PGH involves the close integration of an Environmental Impact Mitigation Plan, which aims to prevent adverse impacts from occurring and keeps those that do occur within an acceptable level; and an Environmental Monitoring Program which provides information that can enable more-accurate prediction of the associated impacts and the necessary feed-back mechanism essential in adjusting the ESMP. The ESMP has as its objectives, finding better alternatives and ways of doing things; enhancing the environmental and social benefits of the road rehabilitation project; avoiding, minimizing or remedying adverse impacts; and ensuring that residual adverse impacts are kept within acceptable levels.

An important activity of the ESMP is the identification of appropriate mitigation measure for an identified impact, which must take into consideration its cost- effectiveness, as this has the potential for significant financial implications. Its implementation however, must effectively address the impact with little or no residual repercussion to the environment. Consequently, continuous mitigation measures will be implemented throughout the Project's cycle to protect and conserve the environment and social setting of the study area as best as possible.

Chapter 9 then provides a summary of the Environmental Management Plan, in tabular form, of the proposed mitigation measures aimed at ameliorating the negative impacts of the environmental issues identified in the impact assessment section of the ESIA.

A monitoring program is recommended with the intention of providing information necessary to ensure that the recommended mitigation measures set out in the design of the rehabilitated road works are implemented in accordance with the requirements of existing legislations and recommended mitigation measures. The parameters chosen for the monitoring program are those that have been identified primarily for the construction phase of the project, since upon completion, the impacts during operation would be minimal and with net positive environmental and social impacts. These parameters include water quality to effectively identify potential water pollution problems associated with road construction, the cause of the problems and the mechanisms to manage any identified issues; and ambient air monitoring to address the control of fugitive and airborne dust emissions as well as vehicular exhausts emissions and vehicular noise generation above normal. The Environmental Management Plan ends with a guide for assessing the costs associated with monitoring environmental impacts and reporting these activities to the DOE and PMU.

The second part of this chapter treats with the Social Management Plan. The Social Management Plan (SMP) describes the overall management and monitoring of these mitigation measures. It specifies the responsibilities, timings, institutional structures, human resources, and estimated annual costs required to effectively implement MOW's social management plan.

It goes on to outline management measures that have been developed in order to minimize or avoid negative Project impacts and maximize Project benefits. This includes Social Impact Management Measures which outlines specific mitigation and management measures for each impact identified in the SIA, with a description of the social performance targets that MOW and its Contractors will strive to meet, measured using specified Key Performance Indicators (KPIs); and the Management of Social Risks which will be managed through mitigation and a Participatory Public Participation Process, inclusive of a Grievance Mechanism, and developing good relationship with stakeholders and PAPs through effectively managing impacts. The Management of Social and Mitigation Measures are then outlined in tabular form.

Chapter 9 ends with a Consolidated Social and Environmental Management Plan and a table summarizing the indicative cost of major mitigation measures contained in the ESMP.

Chapter 10: Public Participation Process

Chapter 10 deals with Public Participation which is not only a statutory requirement, but a process that is designed to provide interested and affected parties with the necessary and sufficient opportunities to: provide local knowledge on the Project Area; raise issues of concern; identify and confirm issues requiring further investigation in the impact assessment; influence project decisions; evaluate the results of environmental and social impacts and suggest enhancement/mitigation thereof.

Through informed and transparent public participation of interested and affected parties, effective social and environmental management/mitigation measures can be established and implemented. This chapter also describes the methopdology used to accomplish maximum pubic participation.

Key to the success of the PPP and an overall underpinning strategy of the BET team in this process was engagement of the village chairpersons/councillors from the PAPs communities as the first points of contact. This served not only to validate the legally established leadership in these communities, but also paved the way for the Team to better understand the socio-economic and political context of the communities, map community assets and build excellent rapport for future engagement. A summary of issues and concerns and recommendations voiced by the PAPs is also presented.

CHAPTER 1: PROJECT DESCRIPTION

1.0 Introduction

The Government of Belize (GOB) developed a National Climate Resilient Investment Plan (NCRIP) and secured funding from the World Bank to address the impacts of climate change on social and economic development. The development objective of the Project is to enhance the resilience of critical road infrastructure against flood risk and impacts of climate change and to improve Belize's capacity to respond promptly and effectively in an "Eligible Crisis or Emergency", as required.

This plan was elaborated with support from the Bank and financial support from the Africa Caribbean Pacific (ACP) European Union (EU) Natural Disaster Risk Reduction Program, received through the Global Facility for Disaster Recovery and Reconstruction (GFDRR). Adopted on October 2013, this multi-sectoral plan lays out priority investments by sector, integrating physical interventions with capacity building activities and policy actions, to quantifiably reduce vulnerability and build climate resilience in the country. In the past, Belize's legislation and policy measures to mainstream disaster risk management (DRM) were fragmented and lacked ownership and participation of ministries. To address this disconnect, the NCRIP engaged all relevant stakeholders from the beginning to devise holistic and participatory approaches to address climate resilience. Through the NCRIP, the GOB has articulated a plan that seeks to fully integrate climate change adaptation, climate variability, and comprehensive disaster management into national development planning processes and actions.

Through the NCRIP, the GOB made great strides to prioritize road infrastructure investments for enhanced climate resilience based on two considerations: (a) socio-economic criticality of the road network; and (b) flood susceptibility of the primary and secondary road networks. Criticality of the roads was assessed through a participatory multi-criteria evaluation (MCE) process with government and key stakeholders such as Non-Governmental Organization (NGO) representatives and the private sector, while the flood susceptibility was carried out using a data-driven analysis. The results from the MCE process and the flood susceptibility evaluation were used to identify priority areas for investments. This investment prioritization served as a basis to inform sub-project selection and components of the Belize Climate Resilient Infrastructure Project (BCRIP).

1.1 The Belize Climate Resilient Infrastructure Project

The BCRIP investment framework in the four selected areas is based on the NCRIP. The criteria for sub-project selection are: (i) take an integrated and comprehensive approach to address climate resilience in the transport infrastructure incorporating hazard mapping, flood risk management and data-informed decision making; (ii) have high impact on socio-economic activities in Belize, increasing both productivity and service delivery; (iii) take into account ongoing or planned investments by the GOB or other International Financial Institutions or bilateral donors; (iv) meet safeguards screening to ensure compliance with the environmental safeguards category; and (v) demonstrate economic viability through an economic analysis.

The BCRIP finances climate resilience activities under the following four mutually reinforcing components: Climate Resilient Infrastructure, Technical Assistance for Improved Climate Resilience Management, Project Management and Implementation Support, and Contingent Emergency Response. **The Philip Goldson Highway from miles 8.5 to 24.5 has been identified by the Ministry of Works (MOW) as the first sub-project site under the Climate Resilient Infrastructure component.**

1.2 The Need for the Rehabilitation of Miles 8.5 to 24.5 of the PGH

The Philip Goldson Highway (PGH), formerly known as the Northern Highway, is critically important to the country's social and economic fabric, as it links Belize City the commercial and economic centre of Belize with the two northern towns of Orange Walk, the Sugar Capital, and Corozal adjacent to the Corozal free Zone and Mexico's Southern Border.

The areas serviced by this section of the highway are critical to the country's agricultural sector as it is a major artery for the delivery of agricultural produce from some of the country's most important agricultural lands. It also services the economically important tourism sector in the area and provides the link to many important tourism destinations such as Altun Ha, Lamanai, Crooked Tree Wildlife Sanctuary, and the Bermudan Landing Baboon Sanctuary.

Of equal importance is the fact that this section of the highway is a part of the Pan American Highway, linking the rest of Central America with Belize. As an international highway then, the Philip Goldson Highway, including this section, must be constructed to international standards.

The rehabilitation of this section of the PGH is proposed to be done in accordance with AASHTO standards.

The PGH is a two-lane, 92.1-mile highway, originally built in the early 1980s to upgrade the old Northern Highway, and was resealed approximately 13 years ago. Since then, the roadway´s pavement has deteriorated significantly, in particular between Ladyville (mile 8.5) and Gardenia Village (mile 24.5), due to: (i) insufficient/poor drainage; (ii) the sharp increase in truck and bus traffic transporting workers and commerce in and out of Belize City, and to a lesser extent, the agriculture and tourism sectors; and (iii) limited maintenance. The pavement's poor conditions together with the absence of paved shoulders, unsafe road alignments, lack of pedestrian facilities in urban areas, and limited marking and signage add to Belize´s high incidence of road fatalities.

Flooding and a failing pavement greatly restrict mobility along the road and make evident infrastructure vulnerabilities during extreme weather events. This is significant as the highway is a primary evacuation route for coastal areas and the Cayes including Belize City. Of particular concern is the stretch from the Airport Junction (mile 9.5), susceptible to flooding, located in Ladyville. Another stretch is the section near Mexico Creek Bridge which has been submerged with about 6 inches of water for a half mile distance at least twice in the last ten years and frequently has water straining the superstructure at Mexico Creek Bridge (mile 20.5). Gardenia Village alongside this stretch of Highway lies in a floodplain and villagers are affected by the flooding of Mexico Creek. Figures 1.1 and 1.2 are scenes of significant flooding along a section of the PGH in Ladyville. The flooding of various sections of the PGH in the project zone was generated by an intense tropical disturbance moving over Belize on August 27, 2007.

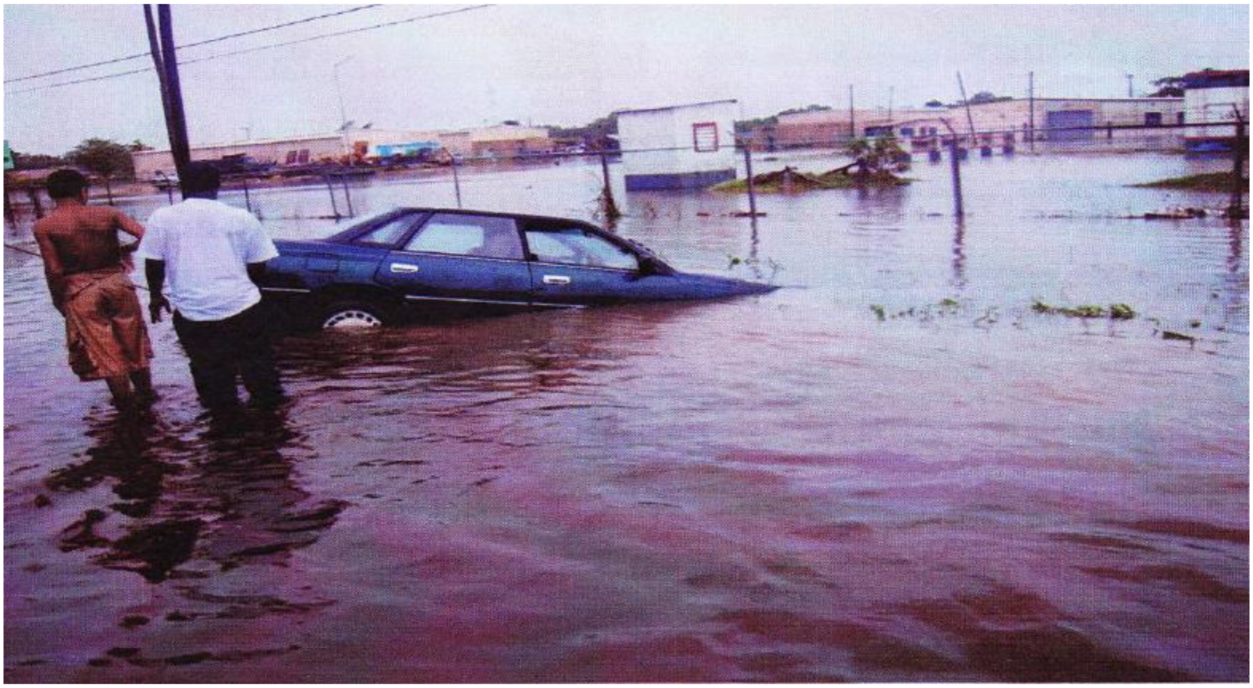


Figure 1.1: Flooded section of the PGH in Ladyville caused by torrential rains associated with a tropical disturbance on August 27, 2007.

Figure 1.2: Another scene of flooded section of the PGH in Ladyville caused by torrential rains generated by a tropical disturbance on August 27, 2007.

The Belize National Evacuation Plan identifies these issues associated with the PGH as critical and in need of urgent attention. It recommends that roads be constructed in such a way as to ensure that they will remain open in order to allow threatened populations to be evacuated. Alternate roads should be constructed or upgraded in cases of loss of the primary evacuation route and that projected peak evacuation traffic loads should be factored into road designs.

1.3 The Study Area

This 16 mile segment of the Philip Goldson Highway Study Area is partitioned into 2 sections for the purposes of this ESIA, as follows:

(i) Section 1 Vista del Mar Junction re-design and 200m East of Airport Junction in Ladyville at mile 8.5 to Burrell Boom Junction at mile 14;

(ii) Section 2: Boom Junction to mile 24.5, PGH near Gardenia Village (Table 1.1).

Table 1.1: BET's Defined Road Sections.

Road Section	From	To	Distance	
			mi	km
1	Mile 8.5 at 200m East of the Airport Junction in Ladyville (w/ inclusion of Vista del Mar junction re-design)	Burrell Boom Junction	5.5	8.8
2	Burrell Boom Junction	Mile 24.5 Gardenia/Biscayne Villages	10.5	16.8

As can be seen from Figure 1.3 section one of the project area shows the road passing through what can be considered as an urbanized area while section two passes through more a rural setting.

Conceptually, the Study is organized around the road development life cycle and for ease of analysis, breaks the existing Right of Way (ROW) into two (2) road sections as shown in Table 1.1, and considers a study area of four kilometres on either side of the highway (Figure 1.3).

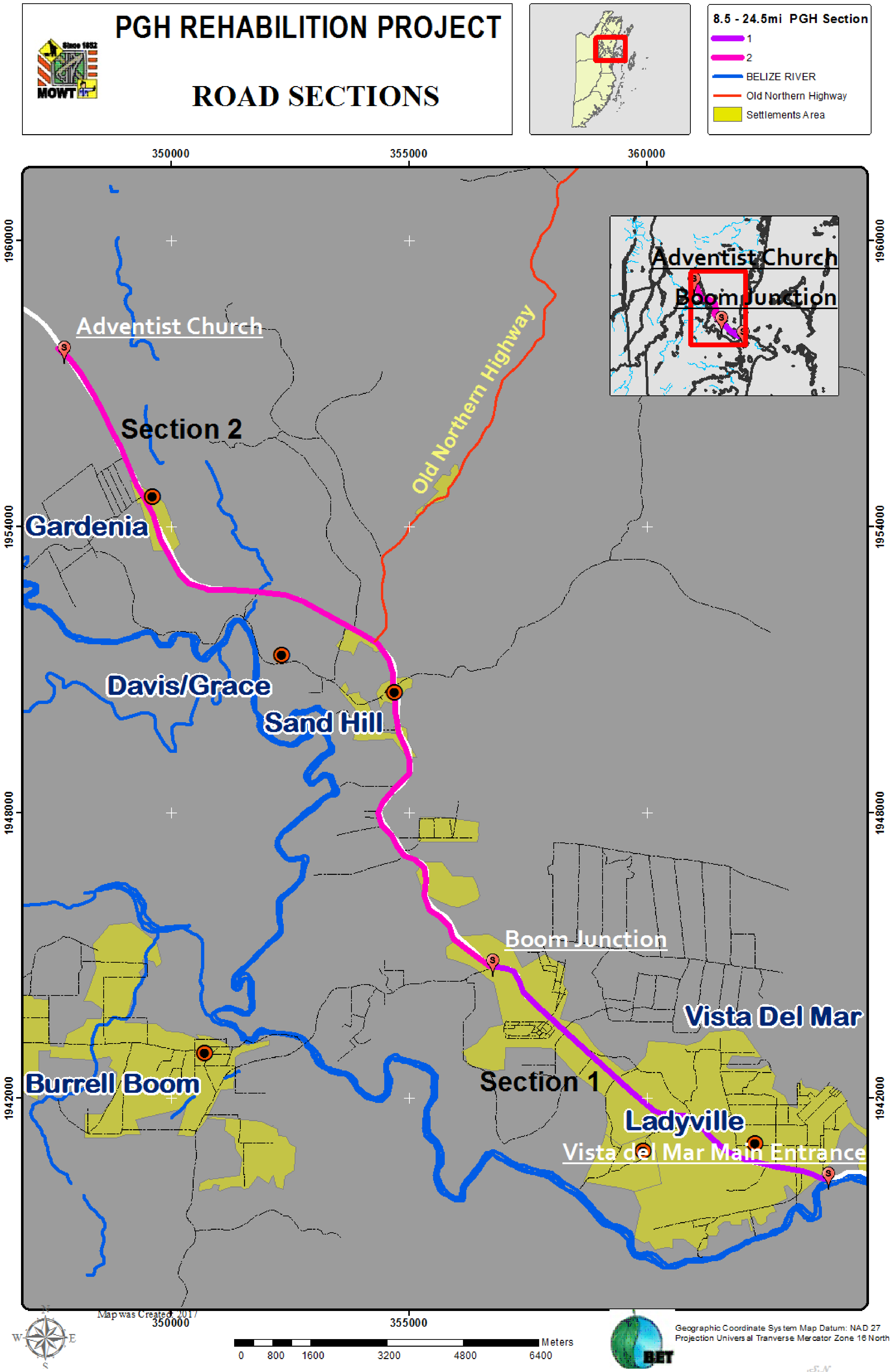


Figure 1.3: Study Area (Miles 8.5 – 24.5).

The proposed rehabilitation section (miles 8.5 – 24.5) of the PGH traverses the lower sub-catchment of the Belize River watershed; a characteristically flood-prone region of the Belize District. The study area is defined as a band four kilometres east and four kilometres west of the centre line of the current road which includes the villages of Ladyville, Lord's Bank, Sandhill, Gardenia, and one and a half miles into Biscayne.

The micro-catchments in the zone are: Mexico Creek, Mussel Creek, and Black Creek. The vulnerability of this section of the highway was very evident during recent extreme weather events (TD 16, 2008; Hurricane Keith 2000); resulting in failing pavement, bridge infrastructural damage, and traffic disruption.

The PGH is a primary transit artery and evacuation route for coastal communities, including Belize City and the Cayes. Specifically, the sections of the highway most vulnerable to floods are the Ladyville area, and the section around Mexico Creek Bridge which has been submerged with half-a-foot to one foot of floodwater for about half-a-mile distance on two or more occasions during the past ten years; while high-energy flood waters through Mexico Creek have strained the Mexico Creek Bridge infrastructure.

Further up at Gardenia Village, the highway runs through a floodplain, with wetlands or 'bajos' on either side. The Village is often affected by flood water from nearby Mexico Creek, making life during these periods unbearable for residence, coupled with water-borne pests and diseases.

Portions of the highway are also submerged by one-foot or more of flood water in some sections during intense weather events. Extended sections of major roads and feeder roads connecting to the PGH were inundated during the TD-16 2008 floods, and communities were only accessible by boats. For example, the Grace Bank and Davis Bank entrance, near the Mexico Creek Bridge, has high energy water flowing parallel to the highway, cutting off villagers from these communities. Figure 1.4 shows a flooded section of the Burrell Boom road caused by excessive runoff and overflowing of the wet lands in the area during the TD-16 2008 flood event.

Figure 1.4: Flooded Section of the Burrell Boom Road west of the Boom Bridge during the TD-16 2008 Major Flood Event.

1.4 Expected Project Outputs

The Project has four main outputs that are expected to address several critical issues as outlined below:

v) Existing Pavement and Drainage Rehabilitation of Miles 8.5 – 24.5 of the PGH between Ladyville and Gardenia[/Biscayne Villages][1];

vi) Construction of a link canal from PGH to Vista Del Mar Canal to reduce the duration and extent of flooding in Ladyville;

vii) Restoring original cross section of Mexico Creek, and cleaning of Mussel Creek and Black Creek to improve hydraulic efficiency and reduce the incidence of flooding of surrounding villages; and

viii) Mitigating the flooding of Mexico Creek and other susceptible areas along the route (the Project).

[1] N.B. Gardenia Village ends at Mile 23 (Personal conversation with Mr. Polin Moralez whose land is situated at this milepost).

CHAPTER 2: ROAD AND INFRASTRUCTURE CONDITIONS

2.1 Introduction

The following information contained in this section of the report has been synthesized from the various assessments (road pavement, culvert, bridge and traffic) conducted by the MOW and Belize Environmental Technologies (BET) key personnel in preparation for the anticipated Rehabilitation of miles 8.5 – 24.5 (km 13.6 – 39.2) of the PGH between Ladyville and Gardenia /Biscayne Villages.

2.2 General Road Conditions

The entire project road section road base and sub-base was stabilized and layered with a flexible type of pavement which was finished with a double surface dressing to the pavement surface.

The section of road between the Vista del Mar Junction and the airport road junction at mile 8.5 was resurfaced in early 2017. The width of the pavement in this section including the paved shoulders is approximately 34 feet. The construction works are ongoing. Pending are the line marking/road studs, erection of signs and the completion of the installation of lamp poles. Noted is the absence of safety features for pedestrians and cyclists which are to be provided, especially in urban areas.

The section of road from the airport junction at mile 8.6 up to Gardenia /Biscayne Villages at mile 24.5 was last resurfaced approximately 15 years ago. The resurfacing was a single surface dressing made to stop the stripping of the aggregates from the paved surface.

The condition of the road surface ranges from fair to poor over different sections of the road. The pavement surface with the poor condition is located between the Lake Garden Community junction at mile 11.25 and Los Lagos Community at mile 13.5. The field reconnaissance revealed the absence of guardrails in highway sections that had steep embankments. These highway sections are to be identified and guardrails provided with impact attenuators. The remaining sections have a running surface that is in fair conditions.

Horizontal alignments and some vertical alignments of the road will be required between the Airport Road junction with the PGH and Old Northern Highway junction with the PGH. Note, however that the highway`s horizontal geometric requirements are to be contained within the road right-of way. Road super-elevation is minimal and has contributed to accidents by speeding vehicles. The carriageway width is not uniform in this section of the road, which has been caused by the gradual breaking of the pavement edge. The road shoulders are not paved. Paved surface and shoulders have differences in level of up to 4 inches. Trees growing along certain sections of the roadside do not allow for good visibility and their removal will need to be considered. Road signs are lacking or in need of maintenance for pedestrian crossings, speed bumps, speed limits, school zones and speed limits, destination, warning and informative signs. Urban areas are to be provided with safety features for pedestrians and cyclists.

2.3 Drainage

The entire project area is located within what is classified as the northern plains. The study area containing the PGH lies within a landscape dominated by lowland savannah wetlands and associated lagoons, streams and a section of the Belize River. The highway itself acts as a dam, disrupting the natural drainage of the area, a situation that has probably contributed to the current intermittent flooding affecting communities along the PGH. The hydrological study is to provide a solution for the flooding and damming effect.

The longitudinal side drains are filled with wetland vegetation that strives in stagnant water particularly the section of the highway that passes through the Ladyville Village. The water table in the height of the dry season in the month of April was measured to be approximately 22 inches below the pavement edge.

The water flow in this area is very limited and has been exacerbated by the land filling activities associated with land development that has increased in the recent years with minimal consideration for proper drainage. The construction of the accesses to these road side properties were made with no regards to culvert invert levels that would allow the free flow of water. Furthermore, the longitudinal side drains have no defined turnouts to remove the storm water runoff from the side drains (Figure 2.1). Culverts were placed to act as balancing culverts. However, development over time by property owners along the highway has reduced the wetland areas that stored excessive storm water. Also there has been an increase of intense rainfall in the project area.

Figure 2.1 Longitudinal side drains Ladyville Village.

In the Lord's Bank junction area leading up to the junction with the old Northern Highway there are no defined longitudinal side drains which might have been silted up over time and overgrown with vegetation. The pavement structure in this area was just built higher than the natural surrounding area and culverts were installed to connect water bodies.

Figure 2.2: Longitudinal side drains are not defined between the Lord's Bank junction area up to the junction with the old Northern Highway.

In the section of road from the junction of the old Northern Highway with the Philip Goldson Highway up to the Gardenia/Biscayne Villages (mile 24.5), the longitudinal side drains have silted up and are overgrown with vegetation. Accesses to private property have been constructed with and without culverts. In addition, several of the culverts are either too small or partially blocked. Water logged areas are being filled up to make provision for development. There is limited provision for channelling water away from the pavement structure. Private developers have in some instances provided longitudinal drains parallel to the PGH but these again have no definite channelization for the removal of the water away from the pavement structure.

Figure 2.3: Longitudinal side drains are overgrown with vegetation and being filled up for new development between the junction of the old Northern Highway with the Philip Goldson Highway up to the Gardenia/Biscayne Village (mile 24.5).

2.4 Condition of Mexico Creek Bridge and Culverts

Mexico Creek Bridge

The Mexico Creek Bridge structure is a two-lane bridge with shoulders and two sidewalks. The bridge is composite structure consisting of reinforced concrete deck and steel beams. The sidewalks are 2 feet and 6 inches wide with handrails. The bridge provides support for the Belize Water Services Limited (BWSL) potable water main on the western side of the structure.

The bridge is considered to be in good structural condition with minor maintenance requirements identified. The maintenance could be in the form of painting to the structural beams to prevent corrosion, the cleaning of the deck drainage to avoid the accumulation of water on the deck surface, repair/painting to damaged handrails, and the cleaning of the waterway to allow for the flow of water under the bridge. The provision of proper signage to indicate the bridge approach and location are outstanding. In addition, a structural evaluation of the Mexico Creek Bridge is recommended with due consideration to the bridge load requirements of the Ministry of Works since the movements created by vehicular traffic seems to be on the high side (MOW personal communication).

The bridge coordinates are provided in Table 2.1 and the location in Section 2 is shown in Figure 2.4a and b.

Table 2.1 Mexico Creek Bridge, location coordinates, and pictorial.

Name	WGS 84		Comments	Photos	
	Lat.	Lon.			
Mexico Creek Bridge	**17.65553**	**88.39571**	**Composite superstructure. Width 34 feet, span 47 feet 8 inches.**		

Material that was used either for the temporary bypass or as coffer dams while the bridge was being constructed, was not properly extracted, and now restricts the proper flow of the Mexico Creek affecting the proper draining of the Jones and Mexico Lagoons during the dry season. An assessment of the bridge foundation is recommended to determine whether the imported material on the stream bed can be removed or not without causing any adverse effects such as scouring to the bridge sub-structure proper or the bridge approach (Figure 2.4).

Figure 2.4: AB (North)-Mexico Creek Bridges showing impounded water from Jones Lagoon and BA (South)-dry creek just before Mexico Creek Bridge.

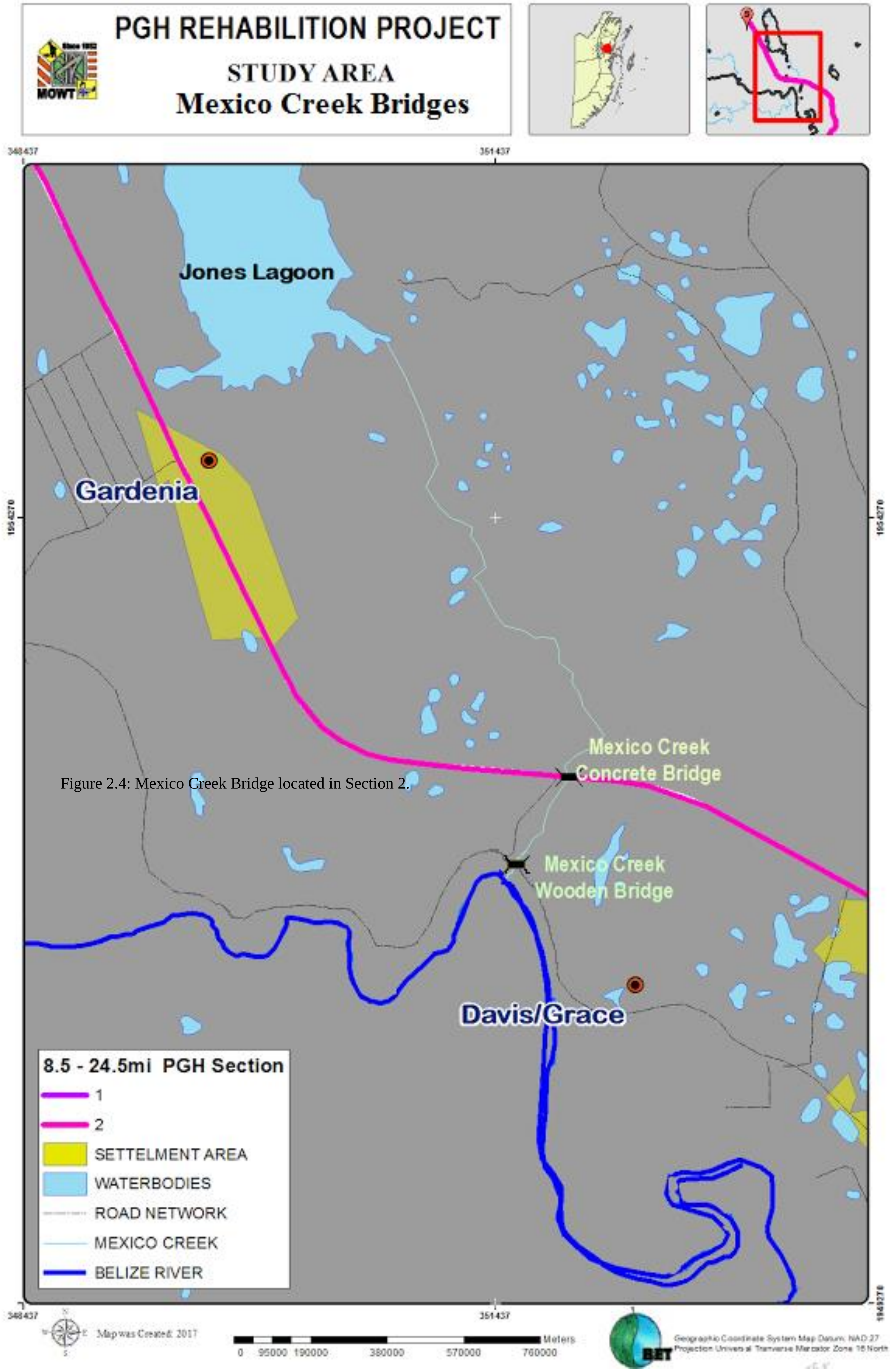


Figure 2.4: Mexico Creek Bridge located in Section 2.

Figure 2.5: Mexico Creek Bridges location

Culverts

Using the culvert inventory list prepared by MOW (Annex III) for the project highway section, BET personnel conducted field visits and identified culvert locations along the project route as well as assessed their condition. The MOW inventoried 33 culverts; however, 36 culverts were identified during the field reconnaissance for which the location by coordinates, material type and size of culvert are provided (Table 2.2). Eleven culverts were identified in Section 1 and twenty-five in Section 2. BET could not confirm if these two additional culverts were an omission from last survey list or simply new ones installed since the MOW survey conducted.

The review and field visits confirmed the different type of construction material of which the culverts were made and the sizes. Many of the culverts were either almost completely blocked or partially blocked and several appeared to be too small.

Of note is the continued use of High-Density Polyethylene (HDPE) and Armco (corrugated galvanized steel) culverts along the project route. Reinforced concrete cylindrical culverts have also been used to replace damaged culverts. It should be noted that the MOW requires that reinforced concrete cylindrical or box culverts be used in the construction of any major highway. A 36 inch minimum diameter is recommended for the cylindrical culverts.

The Armco type culverts have a tendency to corrode at the water fluctuation level area. Welded steel drums culverts encased in concrete were also used as stay in place formwork, which has corroded. The HDPE culverts were observed to deflect or deform under the vehicular loads leading to the deformation of the pavement structure. Recommendation is made for RC culverts either cylindrical or box type be used since these have a longer service life and can be designed to carry expected vehicular loads safely without affecting the pavement structure. The RC culverts are not a fire hazard when compared to HDPE culvert which is a petroleum-based plastic that is combustible and which has been used to replace ARMCO type culverts along the project section. Natural and manmade fires can cause the failure of HDPE culverts on critical project section of the highway used for evacuation in the event of emergencies. The RC culverts are less likely to be washed away during a storm event because of its self-weight when compared to the HDPE culvert.

Table 2.2: Culverts in both Sections 1 and 2.					
#	WGS 84		Comments/ Description	Photos	
	Lat.	Lon.			
1	17.54557	-88.28530	New reinforced concrete (RC) cylindrical culvert 36 inches, internal diameter. RC culvert headwalls.		
2	17.54588	-88.28610	New reinforced concrete cylindrical culvert 36 inches, internal diameter. RC culvert headwall one was covered with a RC v-drain.		
3	17.54614	-88.28688	New reinforced concrete cylindrical culvert 36 inches, internal diameter. RC culvert headwalls		
4	17.54618	-88.28728	Existing reinforced concrete cylindrical culvert 36 inches, internal diameter. No culvert headwalls		
5	17.54682	88.29143	Existing reinforced concrete cylindrical culvert 48 inches, internal diameter. One RC culvert headwall one end was covered.		
6	17.54729	-88.29383	2 # existing concrete cylindrical culverts 30 inches internal diameter. One RC culvert headwall		

7	17.55243	-88.30619	Existing HDPE[2] cylindrical culvert 24 inches internal diameter. No culvert headwalls.		
8	17.55609	-88.30983	Existing Armco[3] cylindrical culvert 18 inches internal diameter. Culvert is encased in concrete. No culvert headwalls.		
9	17.56460	-88.32589	3 Barrel -Existing Armco cylindrical culvert 18 inches internal diameter. Culvert is encased in concrete. No culvert headwalls.		 BTL utility pipe BWSL Supply Pipe BWSL water main
10	17.57031	-88.33274	Existing Armco cylindrical culvert 30 inches internal diameter. Culvert is completely blinded on the west side. No culvert headwalls		
11	17.57963	-88.34343	Existing Armco cylindrical culvert 36 inches internal diameter. Culvert is encased in concrete. No culvert headwalls.		
12	1758441	-88.34651	Existing Armco cylindrical culvert 30 inches internal diameter. Culvert is severely corroded. No culvert headwalls		

[2] High-Density Polyethylene (HDPE) Culverts

[3] Corrugated galvanized steel culverts produced by ARMCO

13	17.58866	-88.35456	3 # existing concrete cylindrical culverts 30 inches internal diameter. One RC culvert headwalls.		
14	17.59194	-88.35765	Existing Armco cylindrical culvert 18 inches internal diameter. Culvert is encased in concrete. No culvert headwalls.		
15	17.59534	-88.36094	Existing HDPE cylindrical culvert 36 inches internal diameter. No culvert headwalls		
16	17.60475	-88.36468	Existing reinforced concrete cylindrical culvert 24 inches, internal diameter. No culvert headwalls.		
17	17.60733	-88.36820	Existing reinforced concrete cylindrical culvert 20 inches, internal diameter. Culvert headwalls are damaged.		
18	17.61736	-88.37023	Existing reinforced concrete box culvert 16 x 28 inches. No culvert headwalls.		
19	17.62120	-88.36668	Existing reinforced concrete cylindrical culvert 18 inches, internal diameter. With concrete culvert headwalls.		
20	17.62438	-88.36646	Existing steel cylindrical drum culvert 20 inches internal diameter. Culvert is encased in concrete. With concrete culvert headwalls.		

21	17.62760	-88.36760	Existing steel cylindrical drum culvert 36 inches internal diameter. Culvert is encased in concrete. Rubble masonry culvert headwalls.		
22	17.62936	-88.368405	Existing corrugated steel 30 inches internal diameter. Culvert is encased in concrete. East side ½ filled with sediment		
23	17.63122	-88.368888	Single Armco culvert 36 inches, internal diameter. With RC culvert headwalls.		
24	17.64042	-88.369515	Newly replaced single reinforced concrete cylindrical culvert 24 inches, internal diameter. With no RC culvert headwalls.		
25	17.64759	-88.37576	Single reinforced concrete cylindrical culvert 24 inches, internal diameter. RC culvert headwalls.		
26	17.65512	-88.39177	Quadruple reinforced concrete cylindrical culvert 42 inches, internal diameter. RC culvert headwalls.		
27	17.65782	-88.41036	Existing Armco cylindrical culvert 24 inches internal diameter. With RC culvert headwalls.		
28	17.66000	-88.41250	Newly replaced single reinforced concrete cylindrical culvert 24 inches, internal diameter. With no RC culvert headwalls.		

29	17.66196	-88.41355	Existing Armco cylindrical culvert 24 inches internal diameter. With RC culvert headwalls.		
30	17.67252	-88.41908	Single reinforced concrete cylindrical culvert 24 inches, internal diameter. With no RC culvert headwalls.		
31	17.67782	-88.42178	Single arch culvert 12 feet in diameter. Has only one head wall. Base of culvert is corroded.		
32	17.68264	-88.42430	Single reinforced concrete cylindrical culvert 24 inches, internal diameter. With RC culvert headwalls.		
33	17.68489	-88.42545	Single reinforced concrete cylindrical culvert 36 inches, internal diameter. With RC culvert headwalls.		
34	17.69057	-88.42847	Double reinforced concrete cylindrical culvert 24 inches, internal diameter. With RC culvert headwalls.		
35	17.69266	-88.42980	Existing double Armco cylindrical culverts 24 inches internal diameter. With one RC culvert headwalls.		
36	17.69749	-88.43320	Existing double HDPE cylindrical culvert 36 inches internal diameter. With culvert headwalls.		

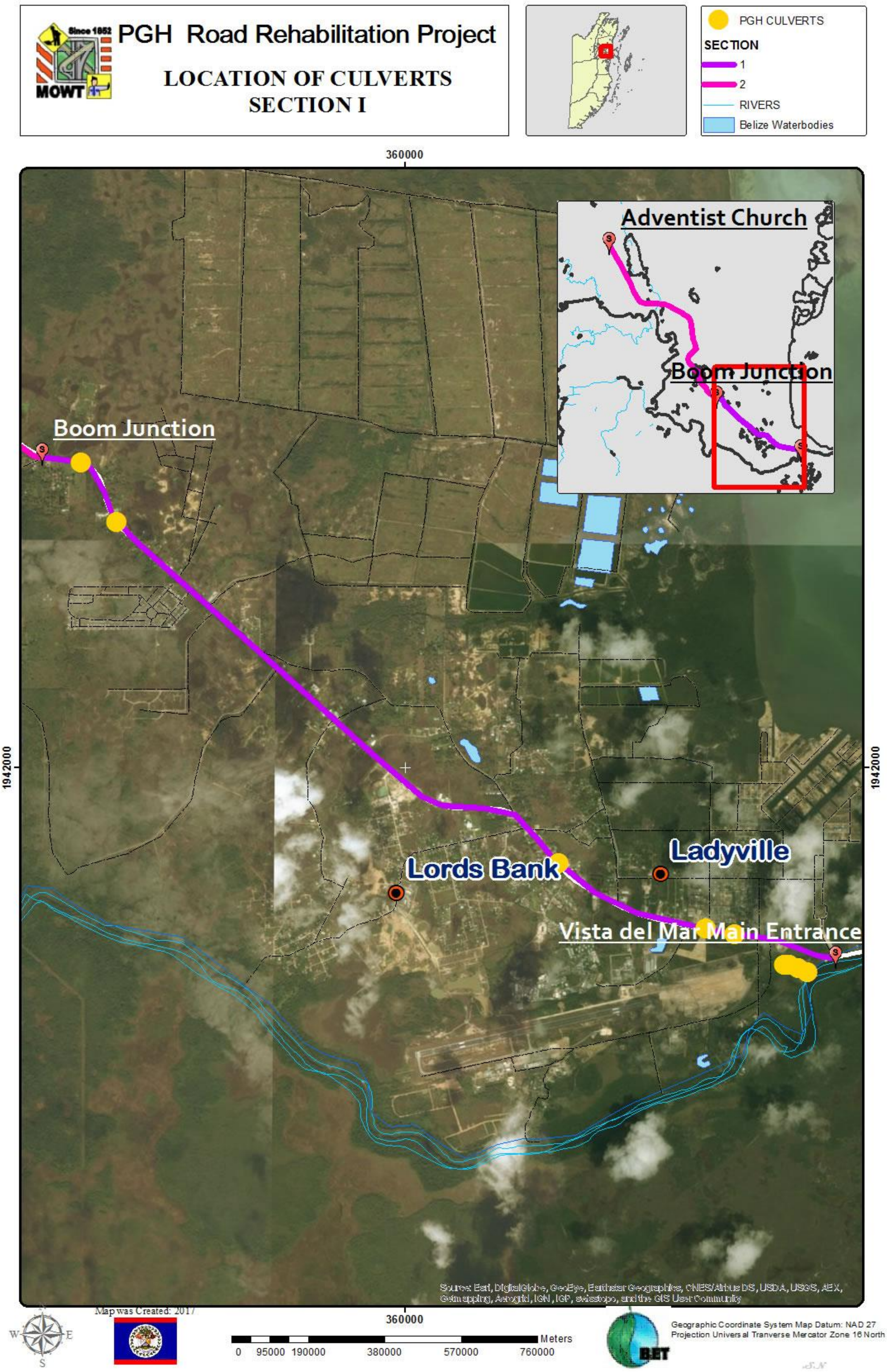


Figure 2.6a: Map showing location of verified culverts for Section 1.

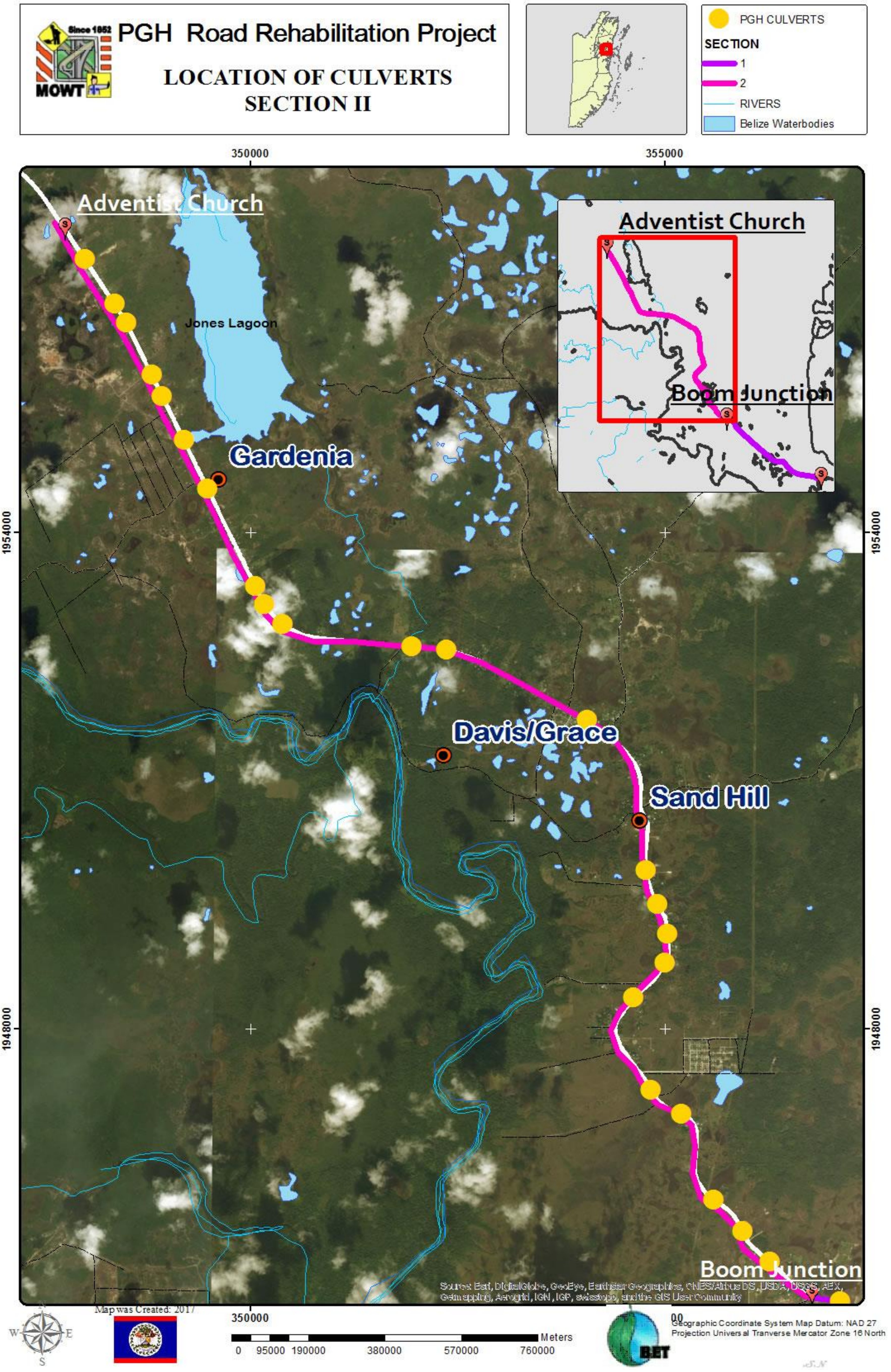


Figure 2.6b: Map showing location of verified culverts for Section 2.

2.6 Traffic Flows

The free flow of traffic on the PGH project section is affected by several problems including the absence of pedestrian facilities such as designated bus stops; all weather shoulders for the movement of pedestrians and cyclists; the temporary parking of vehicles on the carriageway causing the queuing of traffic particularly in peak hours; the frequent turning of vehicles caused by the turning of vehicles on to several accesses/side roads that have direct access to the PGH; the frequency of junctions without merging lanes; and the lack of signage and line markings.

Historical records of traffic counts carried out by the Ministry of Works were obtained from the MOW and the Airport Link Highway Corridor Study of June 2000 prepared by BECA International Consultants. The traffic count data is for location 2 and 3 of the MOW's Belize map showing location of traffic census points.

The historical data was obtained by the MOW's National Traffic Census which was undertaken bi-annually in January and July of each year over a 7-day period (Sunday to Saturday) for 12 hours per day (06.00 to 18.00 hours). Of the 42 points, only two are located in the project section.

Point No. 2 is located 1 mile north of the Airport Road junction with the PGH. Point No. 3 is located 1 mile north of the Burrell Boom junction with the PGH.

The MOW traffic census over the recorded years is an indicator of the average annual growth of traffic in the project area. The average percentage rate of increase for points 2 and 3 are as follows;

Point 2: 1971 – 1979 average growth of 13.80% over 9 years

1989 – 1992 average growth of 11.98 % over 6 years

Point 3: 1971 – 1979 average growth of 19.77% over 9 years

1989 – 1992 average growth of 3.45 % over 6 years

Annex IV show the location of traffic census points, the description of the traffic census location points, and the traffic census data for the years 1971 – 1995, respectively.

Traffic census and axle load surveys were conducted under the Feasibility Study to complement the historical data. It was expected that since 1992, traffic flow on this Section of the highway has increased significantly. This was corroborated by the results of the analysis reported and prepared for Golder by Anthony Thurton & Associates Ltd. (Automatic Traffic Count Report, 2017).

The report identifies three stations where the automatic traffic counts were carried out. The stations that are comparable to the historical data are as follows:

- Station 1 which provides a combined 7-day traffic volume of 3810 which could be compared with traffic census point # 2 of the MOW`s traffic census map which in 1995 had a combined traffic volume of 3455. The difference in the traffic volume is an increase of 355.
- Station 3 which provides a combined 7-day traffic volume of 3574 which could be compared with traffic census point # 2 of the MOW`s traffic census map which in 1995 had a combined traffic volume of 1083. The difference in the traffic volume is an increase of 2491.

The above serves to indicate; a) a traffic volume increase at both points and b) that the local traffic volume increase is small in comparison to the traffic volume to and from the northern districts.

2.7 Critical Areas along Road Sections

The PGH is considered an all-weather arterial road but which has been subjected to flooding in the recent past during extreme weather events. Preliminary findings of the critical areas namely those that are subject to flooding have revealed that quantity, type, diameter and lack of maintenance of the cross-drainage culverts require specific attention. It was noted that some low spots along the highway where runoff was reported to cross over the highway pavement were lacking culverts in several instances and in others the culvert were silted and non-functional. Galvanized metal culverts (Armco and recently installed arch types) were found to be at varying degrees of corrosion. In some instances, the loss of section was complete at the base causing the partial collapse of the culvert. All these identified metal culverts will need to be replaced since

MOW's policy requires that all galvanized steel Armco culverts be replaced. The sizing of the culverts and section is to be reviewed as well.

There are several areas of encroachments, which will be critical particularly if the pavement is to be adjusted within the public right-of-way. The location of the potable water mains and appurtenances (pressure relief valves), the location of buried telecommunications fibre optic cables, power poles are also of concern and will need to be defined to allow for the design and subsequent construction works to be carried out smoothly.

There were also identified a few critical areas where road safety is a major issue. These include the beginning of the Vista del Mar junction exacerbated by patrons to the Manatee Bar parking their vehicles along the edge of the highway and several sharp curves between miles 16 to 18.

2.7.1 Section 1: Bella Vista Community junction at mile 8.5 to Burrell Boom Junction at mile 14 (8.8km)

The highway traverses flat and low-lying terrain with relatively smooth curves throughout its entire length. This section of the highway is susceptible to flooding at two points.

The Ladyville Village portion of the highway was flooded in June 2016 and once again on June 21 June (2017). The flooding has been attributed to the filling of a property estimated to be 14.801 acres in area. The filled lot has a finished fill level higher than the highway surface level and no provision was made for the removal of storm water runoff (Figure 2.7a-e). The drainage of the storm water runoff will require that both longitudinal side drains starting from the Lady of Our Way RC School be re-established to connect with the Link Canal. Recommendation is also being made for the construction of drains along Poinsettia Street up to Perez Road which leads to the Vista del Mar Marina.

Figure 2.7a: Flooded Ladyville Village section of the PGH in 2016. The filled land is to the left of the second photo.

Figure 2.7b: Flooded Ladyville Village section of the PGH in June 21, 2017 (same area as in Figure 2.7a). The filled land is to the left of the second photo.

Figure 2.7c: Flooded Lady of Our Way RC School and Ladyville's Industrial Park on June 21, 2017.

Figure 2.7d: Filled Property infront of Low's Supemarket, Ladyville.

Figure 2.7e: MOW (Belize Office) clearing the clogged drain infront of Low's Supermarket, Ladyville and to the left of the filled property (June 21, 2017).

The pavement structure has had minor flooding at mile 18 after the entrance to the BWSL water treatment plant after heavy rains. The longitudinal drains are non-existent/poorly defined which has been the result of little or no maintenance over the years. Members of the public have constructed earthen drains and concrete lined on the ROW alongside the PGH. Cross drainage-culverts do not function properly due to the high siltation problem. Outlet channels are not defined.

The existing running surface for the most part is in fair to poor conditions with the exception of one mile of pavement structure at the start of the project section which is of recent construction (2016-2017).

Figure 2.8: Pavement surface along Section 1. (Left) Recently surface-dressed pavement with paved shoulders (note no longitudinal side drains); (centre) Pavement in poor condition in the Lagos Community area; (right) Pavement surface in fair conditions with slight surface deformation and broken pavement edges.

2.7.2 Section 2: Burrell Boom Junction to mile 24.5, PGH near Gardenia/Biscayne Villages.

The highway traverses flat and low-lying terrain with relatively smooth curves throughout its entire length. There are potentially three relative sharp curves located between miles 16 and 18, which may require horizontal alignments to improve road safety. The highway`s horizontal geometric requirements are to be contained within the road right-of way.

This section of the highway is also susceptible to flooding in the Mexico Creek area. The pavement structure has been subject to flooding near the Mexico Creek Bridge during the Tropical Depression-16 that occurred in 2008 and during a flood associated with Hurricane Mathew in 2010.

The longitudinal drains are non-existent/poorly defined which has been the result of little or no maintenance over the years. The drains have in most instances, been covered with over grown vegetation impeding the free flow of storm water. Members of the public have constructed accesses to properties fronting the highway with no regards for the placing of culverts to allow the flow of water in the drains. Cross drainage culverts do not function properly due to the high siltation problem. Outlet channels are not defined. Therefore, the lining of the longitudinal side drains is recommended in the flood prone areas of Ladyville Village. In the urban areas theses drains could be covered to act as sidewalks. The lined drains could then be provided with invert levels that would not be obstructed with vegetation that stops the free flow of the storm waters.

The pavement surface in this project section is considered to be fair.

Figure 2.9: Pavement surface along Section 2. (Left) Pavement near the Burrell Boom junction surface in fair conditions, no paved shoulders no line marking and broken pavement edge; (Center) Pavement in fair condition, shoulder drop in dire need of replenishment, signs are outstanding at the old Northern highway junction; (Right) Pavement surface in fair conditions with recently completed shoulder replenishment works which since is not sealed creates a dust pollution problem.

2.8 Road Maintenance

The Ministry of Works undertakes the maintenance of the highway along its entire length within the Project area. Belize Electricity Limited (BEL) carries out vegetation control within the ROW under and around electrical power mains.

The routine maintenance of the highway pavement consists of repairs to potholes in bituminous paved surfaces using premix. Of note is the absence of cleaning and grading of drainage ditches, cleaning, and maintenance of signs, vegetation control within the road reserve, cleaning and minor repairs to culverts, cleaning and minor repairs to bridges.

The periodic maintenance noticed is the shoulder replenishment works. Of note is the absence of a culvert replacement program and resurfacing of the pavement.

2.9 Road Safety

Belize roads and highways have continually experienced a high incidence of fatal traffic accidents.

According to a World Bank Report (2003), lack of investment in road safety such as adequate driver's training and testing, road layout and design, vehicle conditions, police, and judicial enforcement of traffic laws, and human behaviour are also major contributors to road traffic injuries.

A close analysis of the data from 2001-2005 revealed that 35% of all deaths as a result of road traffic injuries, occurred in the Belize District. However, there are several explanations to this. Firstly, the Belize District has one third of the country's population, and therefore has the highest number of vehicles per family.

Most accidents happen on major highways, and involve private vehicles. This has become a frequent occurrence as more Belizeans are moving outside the major cities and towns, and therefore commute on a daily basis.

According to the World Health Organization's Global Status Report on Road Safety (2009), Belize recorded 68 road deaths in 2006, equivalent to approximately 31.1 traffic deaths per 100,000 inhabitants and the highest fatality rate of the Caribbean Development Bank's borrowing member countries for which data was available. In 2009, Belize experienced approximately 70 road deaths per year (WHO 2009). This equated to a rate of 23.6 deaths per 100,000 inhabitants. According to a 2012 Road Safety National Capacity Report conducted by the International Road Assessment Programme (iRAP), within the Latin American and Caribbean Countries, Belize has the highest death rate from traffic accidents per 100,000 inhabitants.

Countermeasures proposed by a 2012 International Road Assessment Programme (iRAP) Belize Final Technical Report for making Belize's roads safer include shoulder widening, roadside safety barriers, delineation, pedestrian crossings, road surface upgrades, pedestrian footpath, signalized intersection, delineated intersection, road side safety hazard removal, bicycle facilities, and lane widening. The International iRAP report further suggests however, that in order to make the road network in Belize safer, efforts that go beyond traditional engineering improvements will be necessary. This includes ensuring that road communities have the opportunity both to contribute to road design and public awareness/education programs.
The PGH Project route currently has no pavement markings which is a basic requirement to reduce traffic accidents. Delineation treatments, including pavement markings, help drivers track the roadway alignment and keep their vehicles within their assigned lanes; centreline markings also identify where passing manoeuvres are, and are not, appropriate on two-lane undivided highways.

The Joint Intelligence Coordinating Center (JICC) of the Belize Police Department which maintains a data base with records of serious and fatal and serious injury crashes and who provided the statistical data in relation to the number of accidents along the project road, indicated the need for the installation of mile posts along the highways to identify specific locations of said accident sites. Notwithstanding this, a recommendation by MOW is for the Road Safety Unit to provide JICC with GPS equipment for logging accident locations. Also a format of required information is to be provided.

In 2011, there were 6 fatal traffic accidents and 7 deaths reported within the Project Area. These accidents occurred between miles 12 and 13, at mile 13.5 (Los Lagos community), mile 16 and 17 and at mile 21.

From the information provided, BET could only glean that in 2012 there were 6 fatal traffic accidents and 6 deaths reported within the project area. These accidents occurred at mile 8, mile 11, mile 9, Mile 23.5 Biscayne village.

Traffic accident data along the project section of the highway is further complemented by the "In-Service Road Safety Review (80% Draft) Philip Goldson Highway, Belize – Mile 8.5 to 24.5" prepared by TransSafe Consulting Ltd for Golder Associates Ltd., (2017). TransSafe further subdivided Section 1 and Section 2 into two sub-sections as shown on Table 2.3.

Table 2.3: TransSafe Philip Goldson Highway Segments.

BET Sections	TransSafe Segments	LOCATION
1	**1A**	**South End (Mile 8.5) to South of Lords Bank Intersection**
	1B	**Lords Bank Intersection to South of Burrell Boom Intersection**
2	**2A**	**Burrell Boom Intersection to South of Old Northern Highway Intersection**
	2B	**Old Northern Highway Intersection to North End (Mile 24.5)**

Of the 57 fatalities between 2014 and 2016, at least 15 were the result of fatal crashes within the study area (based on news reports). The approximate location is available for 9 of them. In addition, 3 were reported to by Ladyville Police (and therefore likely occurred in or around the Ladyville area). The location of the other four crashes was unspecified. The *Source of this information is: Road Safety Project Office.* See Tables 2.4a and b.

Table 2.4a Accident distribution by location.

LOCATION	**DETAILS**
Mile 8/9	Child pedestrian
Mile 9/10	Cyclist
In/Near Ladyville	3 fatal crashes (2 involving pedestrians)
Mile 11/12	Vehicle crashed into abandoned vehicle
Mile 12.5	Vehicle crashed into bus
Mile 18	Pedestrian crash
Mile 19	Pedestrian crash
Mile 19.5 (Sand Hill)	Cyclist hit by a bus
Near Sand Hill	Two motorcycle collided
Mile 22.5	Bicycle on highway hit by vehicle

Table 2.4b: Accident distribution by segment.		
SEGMENT (length)	**FATAL CRASHES (3 YRS)**	**TRENDS**
1A	6	Pedestrians
1B	2	Parked vehicles
2A	4	Pedestrians/motorcycle
2B	1	Bicycle

Countermeasures proposed by a 2012 International Road Assessment Programme (iRAP) Belize Final Technical Report for making Belize's roads safer include shoulder widening, roadside safety barriers, delineation, pedestrian crossings, traffic calming, road surface upgrades, pedestrian footpath, signalized intersection, delineated intersection, road side safety hazard removal, bicycle facilities, and lane widening.

The International iRAP report further suggests however, that in order to make the road network in Belize safer, efforts that go beyond traditional engineering improvements will be necessary. This includes ensuring that road communities have the opportunity both to contribute to road design and public awareness/education programs. Additionally significant benefits could be realized through coordinated targeting of risk factors for road users (such as speeding, seat belt wearing, and alcohol consumption) and vehicles. As observed at a police check point, the police officer was just checking for expired driver's licence, vehicle insurance and vehicle licence while completely ignoring that the occupants in the front of the vehicle were not wearing their seatbelt as required by law.

In conjunction with the iRAP report and considering the population and development growth of the Belize City suburbs along the PGH, the following are recommended in an effort to enhance road safety and the safety of passengers that use the public transport for their daily commute: a) the construction of designated bus stops with lay-bys at major intersections such as Vista del Mar Community; Airport Road; Price Barracks Road; Lord's Bank Road; Lake Garden Community; Burrell Boom Road; Maxboro Community; Old Northern Highway b) the construction of bus lay-bys at educational institutions that border the PGH such as a) Ladyville: Lady of Our Way

RC School, Evangelical School, Ladyville Technical High School and Tubal Vocational Technical Institute ; Sandhill: Guadalupe RC School, and Pancotto Primary School.

Figure 2.10: Road safety concerns at Vista Del Mar Junction mile 8.5 with the PGH. (Left) Illegal overtaking at junction; (Center) utilities are near the pavement edge and (Right) bus stops lay-bys are required.

Figure 2.11: Price Barracks at mile 10 junction with the PGH. (Left)No traffic signs nor line markings to guide drivers; (Center) pedestrian crossing signs one is absent the other in dire need of maintenance; and (Right) pedestrian using the road carriageway as foot path.

Figure 2.12: (Left)Unauthorized covered bus shed too near the edge of the pavement, creating visibility problem; (Center) public transport using Old Northern Highway access road as bus stop this in the absence of a designated bus lay-bys; (Right) missing directional signs at major intersection of the Burrell Boom road and the PGH.

Figure 2.13: (Left) Public transport using the carriageway as a bus stop for the embarkation of passengers; (Center) lack of traffic signs and the need to maintain solar powered caution flashing light; and (Right) no safety signs were noted on this major potable water main installation works along the PGH.

The views and concerns of the communities along the PGH in the Project Area in relation to the road design, safety features, etc. are documented in the Social and Environmental Setting of this ESBA Report.

CHAPTER 3: POLICY AND LEGAL FRAMEWORK

The Policy and Legal Framework in which the rehabilitation of the PGH will take place is made up of national advisory policies which seek to ensure that the activities of the proposed road project are aligned with GOB's national sustainable development goals; a few important MEAs and Belize's environmental and socio-economic laws which protect the environment and the socio-economic well-being of persons who may be affected by the road rehabilitation; and the environmental and social framework of the World Bank which commits the World Bank to sustainable development through its Investment Project Financing, by a Bank Policy and a set of Environmental and Social Standards that are designed to support MOW/GOB's rehabilitation of miles 8.5 to 24.5 of the PGH, with the aim of ending extreme poverty and promoting shared prosperity

3.1 National Advisory Polices

3.1.1 National Environmental Policy

Belize National Environmental Policy and Strategy 2014 to 2024 commits to making Belize *Resilient* by committing to policies for Disaster Risk Reduction and Climate Change Adaptation. From studies done for this ESIA, the rehabilitated PGH in the Project Area will be designed and constructed to withstand known natural and technological disasters; and alternative routes where possible and feasible are suggested for those brief moments when the rehabilitated PGH in the Project Area becomes impassable.

3.1.2 National Protected Areas System Policy and Plan

The National Protected Areas System Policy and Plan recognizes that Protected Areas are an important resource base for the development and strengthening of economic activities and contribute to poverty elimination by supporting industries such as agriculture, tourism, fisheries, timber and non-timber products, research, bio-prospecting, mining, water and energy services among others. As such, and in particular in relation to tourism, a rehabilitated PGH in the Project Area helps to achieve the objectives of the Policy by affording locals and tourists easy access to adjacent tourism related Protected Areas.

3.1.3 National Culture Policy (Draft)

The Government of Belize believes that the Draft National Culture Policy will provide the framework for identity-building and cultural exchange for the purpose of creating a cohesive and improved quality of life so that people throughout the world come to recognize and appreciate Belize's way of life. An improved and resilient PGH in the Project Area will contribute greatly to this desired cohesion by allowing Belizeans of all cultures from the remainder of the Country to interact all year round with Belizeans along the PGH in the Project Area, and vice-versa.

3.1.4 National Gender Policy

The National Gender Policy aims at, *inter alia*, promoting and facilitating women's and men's equal access to, and control over productive resources, services, and opportunities. The employment and service opportunities provided by the rehabilitation of the PGH in the Project Area should therefore be available to both genders equally. BET in this ESIA therefore makes recommendations for the equal participation of women in the PGH rehabilitation project.

3.1.5 Belize Horizon 2030

A key long term goal for Belize up to the year 2030 is to ensure that the Government of Belize is able to make timely investments in key economic infrastructure, especially the road network and transportation system. The rehabilitation of the PGH in the Project Area is therefore a major contributor to the investment needed in our road network.

3.1.6 National Poverty Elimination Strategy and Action Plan

The National Poverty Elimination Strategy and Action Plan recognize that the provision of economic and social infrastructure is salient to a number of poverty reduction initiatives. Road maintenance and construction are recurrent demands on capital expenditure and contribute critically to economic development by linking poor communities to larger population centres, and providing agricultural access, the transfer of goods and the provision of services. A rehabilitated PGH in the Project Area will therefore better serve as a poverty reduction tool to the rural communities along and adjacent its path.

3.1.7 National Sustainable Tourism Master Plan for Belize 2030

The National Sustainable Tourism Master Plan identifies as a main constraint to tourism development in Belize, the poor level of accessibility on land, mainly due to a small amount of paved roads leading to the tourism assets which results in uneven distribution of tourism flow in the country, overcrowding in some sites and underutilization of others. The rehabilitation of the PGH in the Project Area will therefore continue to contribute to ready and easy access, for most of the way, to the many tourism destinations in that area.

3.1.8 Belize National Land Use Policy for Land Resource Development

A guiding principle of the Sustainable Land Use Policy is that climate change adaptation and mitigation issues must be considered and mainstreamed into land use planning. While the rehabilitation of the PGH in the Project Area will take place virtually in the footprint of the existing highway and negligible virgin land would be required for road building, climate change adaptation and mitigation issues will be priority considerations as the PGH is routed nearby to various lagoons and creeks which affects this part of the PGH during rain events.

3.1.9 Government of Belize Policy on Adaptation to Climate Change

One objective of the GOB Policy on Adaptation to Climate Change is to prepare all sectors of Belize to meet the challenges of global climate change. This includes the Transportation Sector in which several of Belize's roads and bridges are vulnerable to seasonal floods. Belize's waterways also become un-navigable during certain periods. Sea level rise and changes in rainfall patterns could increase the episodes of flooding which will impact the nation's transportation. As a result, the Policy tasks the Ministry of Works and the Port Authority to undertake climate change vulnerability studies of the nation's roads, bridges, and waterways and prepare adaptation options to meet these threats. The rehabilitation of the PGH in the Project Area will go some ways in achieving the goals of the Policy.

3.2 Multilateral Environmental Agreements (MEAs)

Belize is a signatory to approximately thirty international conventions, treaties, and agreements that deal in some way or another with the protection of the Environment. Many of these have since found their way into national legislation, particularly in the Environmental Protection Act and its Regulations. These conventions target biodiversity protection such as the Convention on Biodiversity, 1992 (CBD), the Convention on the International Trade in Endangered Species of Wild Flora and Fauna, 1975 (CITES), the Convention on Wetlands of International Importance Especially as Waterfowl Habitat, 1971 (Ramsar),and the Convention on World Heritage Sites, 1972. There are others that focus more on other environmental issues of international concern related to pollution prevention, protection of the ozone layer, climate change and chemicals management and include the United Nations Convention to Combat Desertification (UNCCD), United Nations Framework Convention on Climate Change (UNFCCC), the Vienna Convention and its Montreal Protocol and amendments, Basel Convention, Rotterdam Convention on Prior Informed Consent (PIC), the Stockholm Convention on Persistent Organic Pollutants (POPs), the International Convention for the Prevention of Pollution from Ships (MARPOL), Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1972 and its 1996 London Protocol, the International Convention on Civil Liability for Oil Pollution Damage (CLC and Fund Convention), Oil Pollution Response Cooperation (OPRC), and the Cartagena convention and its Protocols on Oils Spills and Land Based Sources of Marine Pollution.

3.3 National Environmental and Socio-Economic Laws

Belize has in place a very expansive and detailed legal and regulatory framework for sustainable development underpinned by an integrated environmental management approach. This legal and regulatory framework includes national legislations and regulations that address issues of environmental management including pollution control and prevention, natural resource management, biodiversity conservation, protected areas management, preservation of historic and cultural resources, chemicals management, and integrated water resources management. Belize also has in place a robust legal and regulatory framework for the protection of the individual and his/her private property; for the protection of workers and for regulating the conditions of work; for protecting community health and safety; for protecting cultural heritage and for the protection of the right to access to information.

3.3.1 Assessment and Management of Environmental and Social Risks and Impacts

3.3.1.1 The Environmental Protection Act

The Environmental Protection Act (EPA) legislates the role of the Department of the Environment not only as the principal institution with the responsibility for the control and prevention of pollution but also as the national entity with responsibility for coordinating matters related to ensuring the prudent use and proper management of Belize's resources and the protection of the environment.

The EPA entrusts the Department of the Environment with a broad range of functions relating, but not limited to the following:

- the assessment of pollution, and the coordination of activities relating to the discharge of wastes;
- the licensing of activities that may cause pollution and the registration of sources of pollution;
- the carrying out of research and investigations as to the causes, nature and extent of pollution;
- and the enforcement of necessary prevention and control measures.

Also, the Department of the Environment has the responsibility for formulating environmental codes of practices, specifying procedures, practices, or release limits for pollution control relating to works, undertakings, and activities during any phase of their development and operation, including the location, design, construction, start-up, closure, dismantling and clean-up phases, and any subsequent monitoring activities.

In addition to the broad regulatory authority, the Act also provides the Department of Environment with significant investigation, inspection, and enforcement authorities. In fact, the Act contains substantial penalties for violation of pollution control and EIA requirements, e.g., a fine up to BZ$50,000, two years imprisonment, or both. Furthermore, in any conviction for an offense under the Act, the court is authorized to order the offender to take remedial action with respect to the harm caused to the environment, and any person who may suffer loss or damage as a result of an offense may bring a civil action against the offender.

The Act has been amended several times since its passage, with the most recent done in 2009. The 2009 Amendments of the Environmental Protection Act provide for greater environmental control and management of the petroleum industry, to make improved provisions for the protection of the Belize Barrier Reef System, to establish an environmental management fund, to provide for out-of-court settlement in appropriate cases, and to provide for the issue of violation tickets for pollution offences.

The earlier amendments to the Environmental Protection Act also included fiscal and economic incentives for pollution control. Among other things, the amendments made it clear that the Act is binding on the Government, increased the levels of fines and sanctions (including stop orders), and authorized the Department of Environment to charge fees for permits, licenses and applications. The main regulations made under the Act are the Environmental Impact Assessment Regulations (S.I. # 107 of 1995 and its amendment of 2007); the Environmental Protection (Effluent Limitation) Regulations (S.I. #94 of 1995) and its amendment of 2009; the Pollution Regulations (S.I. #56 of 1996) and its amendments of 2009 and the Hazardous Waste Regulations of 2009.

3.3.1.2 The Environmental Impact Assessment Regulations

The EIA process in Belize is comprehensive and follows internationally accepted stages: screening, scoping, EIA, reporting, public consultation, a review process, and the preparation of an environmental compliance plan (ECP). Responsibility for undertaking the EIA and the preparation of EIA report lies with the project proponent, who also has to undertake public consultation, and on completion of the EIA report, publish details of where the report may be obtained so that members of the public can review the report and submit comments on the proposals.

The EIA Regulations set out the information to be included in the EIA report, which must include the establishment of an environmental baseline, description of the proposed project, identification of and prediction of potential impacts, identification of mitigation measures, evaluation of project alternatives, and selection of the preferred alternative, resource assessment and the preparation of an Environmental Management Plan (EMP) to identify any mitigating and monitoring measures to be implemented.

The EIA procedure is controlled by the DOE, which is responsible among other things for determining whether an EIA is required, reviewing, and approving the TOR prepared by the project proponent, determining procedures for public consultation, and directing the evaluation and approval of the EIA report. The EIA Report has to be submitted to the DoE for the review process. The DOE may request additional material and the EIA is not considered to be complete until the developer has supplied all the information requested. The DOE will not adjudicate on the project until this process has been completed satisfactorily. The DOE may make copies of the EIA available to interested persons, will review the EIA against the TOR, and determine whether further studies are needed and note the existence of any significant adverse effects. The DOE will advise the project proponent within 60 days of their decision, during which time the developer must not start the project.

The EIA Regulations established the National Environmental Appraisal Committee (NEAC) as the agency responsible for reviewing ElA reports, advising the DOE of the adequacy or otherwise of the EIA, and advising the DOE on the need for a public hearing. NEAC is chaired by the Chief Environmental Officer, who is also the head of the DOE, and the Committee is made up of representatives from the main environmental government agencies. During the process of evaluation of the EIA, NEAC may conduct site visits and interviews with key stakeholders as part of the consultation process.

The EIA process also calls for various levels of public consultation. This includes meetings with key stakeholders in order to get their views and inputs, local community consultations, the publishing of two notices in a local newspaper publishing the location and dates when the EIA document will be made available to the public for a period of two weeks. Whenever the DOE determines necessary, then a formal public hearing at a community near the proposed site may be required as another form of consultation. A decision on the various levels of consultation is made by the DOE after due consideration of the local context of the project site, the pre-existing conditions, the magnitude and significance of the impacts, among other factors.

During the process of evaluation of the EIA, members of the NEAC may conduct site visits and interviews with key stakeholders as part of the consultation process. At the final stage of approval, the DOE requires the project proponent to sign an Environmental Compliance Plan, a legal document to which the developer must adhere. This document is legally binding and contains the mitigation measures, stages of development, and technology to be used during the various phases of the project. It also makes provisions for monitoring and enforcement of the conditions agreed to and provisions for failure to implement the agreement. In the event that NEAC decides that the project should not go ahead on environmental grounds, the developer may appeal to the Minister.

The regulations divide projects or activities into three categories. Schedule 1 lists those projects that automatically require an environmental impact assessment (EIA) based on the sensitivity of the surroundings or the nature of the undertaking. Schedule 2 lists those projects that may require an environmental impact assessment or a limited level study (LLES) to be carried out, depending on the outcome of an environmental questionnaires or statement. Schedule 3 provides guidelines to be used by permitting and /or licensing agencies to determine when a project, programme, undertaking, or activity is to be sent to the Department of the Environment for environmental clearance.

A Schedule 1 project for which a full EIA is mandatory includes under Schedule I – Infrastructure Projects: - (c) Construction of national highways and roads of more than 10 miles in length.

3.3.2 Labour and Working Conditions

3.3.2.1 The Labour Act and Regulations

Labour relations between contactors and their workers will be governed by the Labour Act which makes provisions for recruiting employees, terms and conditions of employment, payment of wages, dispute resolution, etc.

3.3.2.2 The ILO Convention Act

The International Labour Organization (ILO) Conventions Act lists the ILO Conventions ratified by Belize and which have the force of law in Belize. As such, these Conventions will govern the relation between contractors and their workers as to the particular subject matter of the Convention. These Conventions include, *inter alia,* Minimum Age, Right of Association, Minimum Wage, Freedom of Association, and Protection of the Right to Organize, Abolition of Forced Labour, Radiation Protection, Paid Leave, etc.

3.3.2.3 The Occupational Safety and Health Bill (OSH)

Comprehensive legislation governing workers safety and health have been introduced in the House of Representative in the form of a National Occupational Safety and Health Bill. While this is not yet law, the provisions of this Bill serves as an excellent best practice guide for ensuring the safety and good health of workers involved with the rehabilitation of the PGH in the Project Area.

3.3.2.4 The Law of Contract Act

This Act regulates the making, validity, execution, and dissolution of contracts between workers and employers.

3.3.2.5 The Social Security Act

Workers involved with the rehabilitation of the PGH in the Project Area are assured some monetary insurance by the provisions of the Social Security Act, which requires that contractors pay social security contributions for their employees to assist them in times of sickness or injury.

3.3.2.6 The Protection against Sexual Harassment Act and Regulations

The Provisions of the Protection against Sexual Harassment Act provides for the prohibition of sexual harassment in the workplace by an employer of fellow employees so that both male and female workers will be working in a respectful and pleasing environment.

3.3.2.7 The Workmen Compensation Act

The Workmen Compensation Act applies to workers who are involved with cases of accidents on the job or while being transported to the job. The Act makes provisions for the contactors' liability for compensation, amount of compensation, conditions of compensation, insurance, insolvency, or bankruptcy of the contractor, etc.

3.3.3 Resource Efficiency and Pollution Prevention and Management

3.3.3.1 The Environmental Protection (Effluent Limitation) Regulations

These regulations were established to control and monitor discharges of effluent into any inland waters or the marine environment of Belize; prohibit the discharges of effluent from new and altered sources; implement a licensing system for the discharge of effluents; and establish and implement the requirements for the treatment of effluents. In 2009 this regulation was amended to allow for greater consistency with the Cartagena Convention and the Aruba Protocol on land-based sources of marine pollution. Where any effluent is produced in the rehabilitation of the PGH in the Project Area, arrangement will need to be made with the Department of the Environment for its proper disposal.

3.3.3.2 The Pollution Regulations

These Regulations address issues of air, water, and soil pollution, including noise pollution. Part III – 6 (1) deals generally with the emission of contaminants into the air where no person may cause, allow or permit contaminants to be emitted or discharged either directly or indirectly into the air from any source. Regulation 31 states that no person shall pollute the land so that the condition of the land is so changed as to be capable of making the land noxious or harmful to animals. Regulation 32 provides that no person shall cause any seepage or leaching contamination of the adjacent soil, groundwater, or surface water. Regulation 33 empowers the DOE to issue directions to persons for the elimination of waste or a solid waste treatment plant and disposal system. Regulation 35 prohibits the deposition of waste in a place other than a site approved by DOE for the storage or elimination of waste or operation of a waste treatment plant or waste management system. Finally, regulation 37 prohibits any person from causing or allowing any equipment to emit unreasonable noise from any premises without attempting to abate such noise.

3.3.3.3 The Hazardous Waste Regulations

These regulations establish legal directions for the transportation, storage, and disposal of hazardous waste. Where the storage of any hazardous waste in connection with the rehabilitation of the PGH in the Project Area becomes necessary, it must be done in accordance with section 10 (1) of the regulations. It addresses the prevention of leaks and requires that a secondary containment be provided for the storage of hazardous materials. The regulation requires that hazardous waste is adequately labelled and there is no contact among incompatible hazardous wastes. It also requires that routine inspections are performed and the place where they are stored is secured, prominently identified as a waste storage site, is equipped with suitable equipment to handle emergency situations, is provided with trained operators, has no opening in the secondary containment, and provides no access for surface water to enter the secondary containment.

3.3.4 Community Health and Safety

3.3.4.1 The Public Health Act and Regulations

The health conditions of the workers' camps and that of the communities in which they are located during the rehabilitation the PGH in the Project Area, is governed by the Public Health Act. In the worker's camps and communities, the Public Health Act regulates water supply, drainage, garbage collection and storage, infectious diseases, mosquito destruction, sanitation and prevention of nuisances etc. Also, the Public Health Act makes provisions for ensuring that establishments providing food services are staffed by persons in receipt of Food Handlers Certificates from the Public Health Department and that these food establishments have sanitary toilet and washing facilities.

3.3.4.2 The Family and Children's Act and Regulations

The Act prohibits the Chief Engineer and his contractors from employing any child in a capacity where such employment or engagement in any activity that is detrimental to his/her health, education, or mental, physical or moral development.

3.3.4.3 The Village Council Act and Regulations

Every Village Council is charged with the good governance and improvement of its village including the sanitation of the village, drainage and sewage, the suppression and abatement of nuisances, ensuring sound environmental practices by all persons in the village, etc. Genuine consultations with all the Village Councils affected by the PGH rehabilitation is being undertaken to ensure the acceptance of the Project and its workers into the affected communities, and to afford the communities the opportunity to be a part of the Project design and execution.

3.3.4.5 The Dangerous Goods Act

In situations where contractors may import, produce, transport, store and/or distribute dangerous goods such as explosives, petroleum products, gunpowder, dynamite, nitro-glycerine, gun cotton, blasting powders, fulminate of mercury or of other metals, coloured fires, other similar substances, the Dangerous Goods Act regulates these activities to ensure the safety of the communities in which they are being handled.

3.3.4.6 The Disaster Preparedness and Response Act

The Act allows for disaster hazard inspections of the various work sites of the contractors where a magistrate is satisfied on evidence that the condition of such sites is reasonably suspected of posing a danger of serious injury to persons outside of the sites in the event of a disaster. The magistrate may issue or renew an order authorizing the hazard inspector to enter and inspect those sites for hazards.

3.3.4.7 The Fire (Negligent Use of) Act

The Act provides for a fine and or term of imprisonment for contractors in the event that they negligently use fire which causes damage to properties of whatever kind or nature.

3.3.4.8 The Nuisances Act

The Act provides that where any building or place or any activity of the contractors, whether by land or water, is a nuisance, a summary jurisdiction court may, if it thinks fit, order that the nuisance be abated either immediately after service of the order or within such time as may be reasonable according to the circumstances, and may also if it thinks fit, prohibit the recurrence of the nuisance.

3.3.4.9 The Intoxicating Liquor Licensing Act

The peace and quiet of communities and the protection of minors in villages affected by the rehabilitation of the PGH in the project area is secured by the provisions of the Intoxicating Liquor Licensing Act, in particular section 44 of the Act which prohibits the sale of alcohol to persons under 18 years of age (and consequently their presence in such liquor establishments).

3.3.4.10 The Public Roads Act

It is by authority contained in the Public Roads Act that work on the PGH in the Project Area is made legally possible. The Public Roads Act in section 3 entrusts the Chief Engineer with the responsibility, under the authority, control, and direction of the Minister of Works, with the construction, alteration, maintenance, and supervision of all public roads of Belize, which includes all existing highways. It is therefore with the consent and approval of the Chief Engineer, that the PGH will be rehabilitated in the Project Area.

The Chief Engineer is empowered by the Public Roads Act in relation to any work on any public road, including the work involved with rehabilitating the PGH in the Project Area, to close, divert, prohibit or manage traffic in the public interest; appropriate uncultivated lands; make arrangements for compensation, on behalf of the Government of Belize, with the owners of appropriated cultivated land; lawfully enter upon any land; take material from any cultivated or uncultivated land; erect buildings or place construction debris on any adjacent land; make temporary roads; remove any obstruction or encroachment; or construct tunnels, culverts or bridges on any adjacent land.

The Public Roads Act authorizes the Chief Engineer to acquire land on behalf of the Government of Belize if necessary for the rehabilitation of the PGH; and in section 10 (2), where the Chief Engineer and the owner cannot agree on the compensation to be made for the acquired land, proceedings are taken to take possession of the land and pay compensation in accordance with the Land Acquisition (Public Purposes) Act. Although this is stipulated in the Public Roads Act, government has adopted a policy that all land acquisition be conducted via the Ministry of Natural Resources using the Land Acquisition (Public Purpose) Act.

3.3.4.11 The Motor Vehicles and Road Traffic Act

This Act prohibits that the contractors' workers from driving work vehicles without licenses or authorizations, from driving while under the influence of drink or drugs, and from driving recklessly or carelessly in the communities where the PGH is being rehabilitated.

3.3.5 Land Acquisition, Restrictions on Land Use and Involuntary Resettlement

3.3.5.1 The Land Acquisition (Public Purposes) Act

The Land Acquisition (Public Purposes) Act makes provisions for compulsorily acquiring land for the rehabilitation of the PGH, assessment and compensation, etc. Section 11 (1) of the Land Acquisition (Public Purposes) Act stipulates that all claims related to the payment of compensation under the Act shall be submitted to a Board of Assessment. The Board shall comprise the Chief Justice, or other Judge of the Supreme Court nominated by the Chief Justice, who shall be the Chairman of the Board; a member appointed by the Minister; and a member nominated by the owner of the land to be acquired. An award of the Board may be enforced in the same manner as a judgment or order of the Supreme Court.

The Act will not need to be applied in those instances where there have been encroachments on the road reserves of the PGH, as these lands are already owned by the GOB. All efforts will be made however, to consult which those persons who have encroached on the road reserve and all efforts will be made to assist them as far as possible to relocate their structures/businesses where feasible.

3.3.6 Biodiversity Conservation and Sustainable Management of Living Natural Resources

3.3.6.1 The Fisheries Act and Regulations

The Fisheries Act regulates fishing in Belize as to commercial activities, licenses, scientific research, export, use of poison or explosives, and nets; establishes, controls and regulates marine reserves so as to afford special protection to the aquatic flora and fauna of such areas and to protect and preserve the natural breeding grounds and habitats of aquatic life; allows for the natural regeneration of aquatic life in areas where such life has been depleted; promotes scientific study and research in respect of such areas; or preserves and enhances the natural beauty of such areas.

3.3.6.2 The Forests Act

The Forests Act declares forest reserves and protect trees and forest produce being in or upon such reserve or other areas; regulates the export, import and dealing in wild animals, their products, plants and spices; regulates the transport of forest produce and the unlawful possession of forest produce; declares scheduled truck passes/forest roads on public and private lands; appropriates cultivated land for forest roads; and prescribes royalties for extracting forest produce.

3.3.6.3 The Wildlife Protection Act

The Wildlife Protection Act regulates the hunting, which means the killing, taking or molesting by any method and includes attempting to kill, take or molest by any method any species of wildlife, i.e. all undomesticated mammals, birds and reptiles and all parts, eggs and nests of any of these wildlife forms; and which regulates the possession of any wildlife or parts of wildlife; or regulates the carrying of any gun, spear, trap or other means for hunting wildlife.

3.3.6.4 The National Protected Areas System Act

The National Protected Areas System Act of 2015 establishes a national protected areas system; promotes long-term conservation, management, and sustainable use of Belize‘s protected areas; promotes conservation of ecologically viable areas representative of Belize‘s biological diversity and its natural landscapes and seascapes; ensures maintenance of genetic diversity and the diversity of species and habitats within these areas, including but not limited to threatened species and species of economic, social or cultural value; ensures sustenance of the provision of ecosystem goods and services important for national development, including but not limited to timber and non-timber forest products, fish and other marine resources, genetic resources, water catchment services, removal of pollutants, soil regeneration, pollination, carbon storage, resilience and adaptability to climate change, protection against natural disasters, and natural environmental features of touristic, recreational, cultural or spiritual value; and promotes the strengthening of coordination and collaboration between nature-based protected areas, and archaeological reserves, where deemed necessary.

3.3.6.5 The National Integrated Water Resources Act

The Act provides for the management, controlled allocation and the sustainable use and protection of the water resources of Belize and will therefore apply to all related work on the various lagoons and creeks in the PGH project area.

3.3.7 Cultural Heritage

3.3.7.1 The National Institute of Culture and History Act

The NICH Act protects our cultural assets during the rehabilitation of the PGH in the Project Area in particular in section 62 (1) which prohibits the wilful damage, destruction, or disturbance of any ancient monument, or their marking or defacing, or removal; or the removal or destruction of any antiquity. Another important provision of the NICH Act is section 63 which authorizes the Director of Archaeology to direct any contractor who is about to engage in any operation which in the opinion of the Director is liable to destroy, damage, interfere with or otherwise be to the detriment of any ancient monument or antiquity; not to proceed with any operation until the Director shall have had an archaeological exploration and survey carried out; and to take or to refrain or desist from taking any such action as part of the operation as the Director may decide to be fair and reasonable for the proper protection of the ancient monument or antiquity.

3.3.8 Stakeholder Engagement and Information Disclosure

3.3.8.1 The Freedom of Information Act

The Act provides that all information about the rehabilitation of the PGH between miles 8.5 to 24.5 is made available to the public, as under section 9 of the Act, every person has a right to obtain access in accordance with the Act to a document of a Ministry or prescribed authority, other than an exempt document.

3.3.9 Summary of Legal and Regulatory Operating Framework

Table 3.1 summarizes the legal and regulatory operating framework of the project.

Table 3.1: Legal and Regulatory Operating Framework.

Laws, Regulations, Guidelines, Standards for PGH Rehabilitation	Particular Subject Matter	Likelihood of Being Administered (Not likely, Possibly, Definitely)	Responsible Party
The Public Roads Act	Construction, alteration, maintenance, and supervision works on PGH.	Definitely	The Chief Engineer
The Environmental Protection Act	The assessment of pollution, and the coordination of activities relating to the discharge of wastes; and the enforcement of necessary prevention and control measures.	Definitely	The Chief Environmental Officer
The Environmental Impact Assessment Regulations	Determining whether an EIA is required, reviewing, and approving the TOR prepared by the project proponent, determining procedures for public consultation, and directing the evaluation and approval of the EIA report.	Definitely	The Chief Environmental Officer
The Environmental Protection (Effluent Limitations) Regulations	Control and monitor discharges of effluent into any inland waters or the marine environment of Belize.	Not Likely	The Chief Environmental Officer
The Pollution Regulations	Address issues of air, water, and soil pollution, including noise pollution.	Definitely	The Chief Environmental Officer/Contractors
The Hazardous Waste Regulations	The transportation, storage, and disposal of hazardous waste.	Definitely	The Chief Environmental Officer/Contractors
The Labour Act and Regulations	The payment of Social Security Contributions for workers.	Definitely	The Labour Commissioner/Contractors
The ILO Convention Act	Establish minimum age and wage and the right of association, to organize and to paid leave; and to abolish forced labour, etc.	Not likely	The Labour Commissioner/The Chief Justice
The Occupational Safety and Health Bill (OSH) as a guideline/standard	Establish duties of workers and employers as to safety and health in the workplace.	Definitely	Contractors/Workers
The Contract Act	Establish the validity of contracts between workers and employers, contractors and suppliers, etc.	Possibly	The Chief Justice
The Social Security Act	The payment of Social Security contributions on	Definitely	Contractors/The Chief Justice

	behalf of workers.		
The Workmen Compensation Act	Establish liability for accidents involving workers on the way to work or while being transported to work.		Contractors/The Chief Justice
The Protection Against Sexual Harassment Act and Regulations	The prohibition of sexual harassment in the workplace.	Possibly	Contractors/Workers/The Chief Justice
The Public Health Act and Regulations	Health conditions especially in and around workers camps.	Definitely	Contractors/Workers/The Chief Public Health Inspector
The Village Council Act and Regulations	Community involvement in PGH rehabilitation activities.	Definitely	Contractors/Village Council Chairpersons
The Dangerous Goods Act	The transportation, distribution, and storage of dangerous goods in communities.	Definitely	Contractors/Workers/The Commissioner of Police/A Justice of the Peace
The Disaster Preparedness and Response Act	Inspection of worksites where they pose a danger to persons outside those sites in the event of a disaster	Possibly	Contractors/Workers/A Magistrate
The Fire (Negligent Use of) Act	The negligent use of fire causing damage to property of whatever kind or nature.	Possibly	The Chief Justice
The Nuisances Act	The abatement of nuisances in any building, place or by any activity.	Possibly	Contractors/Workers/The Chief Justice
The Intoxicating Liquor Licensing Act	Peace and quiet in communities, the sale of liquor to minors and the presence of minors in liquor establishments.	Possibly	Village Chairpersons/The Commissioner of Police
The Motor Vehicles and Road Traffic Act	Reckless or careless driving in communities	Possibly	Contractors/The Commissioner of Police
The Land Acquisition (Public Purposes) Act	The compulsory acquisition of land for PGH rehabilitation compensation.	Possibly	The Chief Engineer
The Fisheries Act and Regulations	Regulation of fishing in inland waters, and the protection and preservation of the natural breeding grounds and habitats of aquatic life.	Definitely	Contractors/Workers/The Chief Fisheries Officer
The Forests Act and Regulations	Regulation of the cutting of mangroves in and around wetlands.	Definitely	Contractors/The Chief Forest Officer
The Wildlife Protection Act	Regulating the hunting, possession, etc. of wildlife.	Possibly	Contractors/The Chief Forest Officer
The National Protected Areas Systems Act	Conservation of ecologically viable areas	Definitely	Contractors/National Protected Areas Advisory

	of Belize's biological diversity, maintenance of genetic diversity and the diversity of species and habitats within these areas, and the provision of ecosystem goods and services important for national development.		Council
The National Integrated Water Resources Act	The management, controlled allocation and the sustainable use and protection of the water resources of Belize.	Definitely	Contractors/The National Integrated Water Resources Authority.
The National Institute of Culture and History Act	Prohibits the wilful damage, destruction, or disturbance of any ancient monument, or their marking or defacing, or removal; or the removal or destruction of any antiquity.	Not likely	Contractors/The Director of Archaeology
The Mines and Minerals Act	Grants the right to mine in Belize and regulates all mining activities including the operation of quarries.	Definitely	Contractors/Inspector of Mines
The Freedom of Information Act	The provision of information about the PGH rehabilitation activities.	Possibly	Interested Individuals/The Chief Engineer/The Chief Justice

Licences, Permits, Etc.

Activity	**License/Permit Required**	**Licensing/Permitting Agency**
Construction, alteration, maintenance, and supervision works on PGH.	Environmental Clearance	Department of the Environment
Cutting of mangroves in and around wetlands.	Permit	Forestry Department
Operation of quarries.	License	Geology Department

3.4 The World Bank's Environmental and Social Standards

The ***Environmental and Social Standards*** set out the requirements for Borrowers relating to the identification and assessment of environmental and social risks and impacts associated with projects supported by the Bank through Investment Project Financing. The Bank believes that the application of these standards, by focusing on the identification and management of environmental and social risks, will support Borrowers in their goal to reduce poverty and increase prosperity in a sustainable manner for the benefit of the environment and their citizens. The standards will: (a) support Borrowers in achieving good international practice relating to environmental and social sustainability; (b) assist Borrowers in fulfilling their national and international environmental and social obligations; (c) enhance non-discrimination, transparency, participation, accountability, and governance; and (d) enhance the sustainable development outcomes of projects through ongoing stakeholder engagement.

BET has determined that the following Standards will apply during the rehabilitation of the PGH between miles 8.5 to 24.5.

3.4.1 Environmental and Social Standard 1: Assessment and Management of Environmental and Social Risks and Impacts

This Standard sets out the MOW/GOB's responsibilities for assessing, managing and monitoring environmental and social risks and impacts associated with each stage of a project supported by the Bank through Investment Project Financing, in order to achieve environmental and social outcomes consistent with the Environmental and Social Standards (ESSs).

The objectives of the Standards are:

- To identify, evaluate and manage the environment and social risks and impacts of the project in a manner consistent with the ESSs.
- To adopt a mitigation hierarchy approach to:
  - Anticipate and avoid risks and impacts;
  - Where avoidance is not possible, minimize or reduce risks and impacts to acceptable levels;
  - Once risks and impacts have been minimized or reduced, mitigate; and
  - Where significant residual impacts remain, compensate for, or offset them, where technically and financially feasible.
- To adopt differentiated measures so that adverse impacts do not fall disproportionately on the disadvantaged or vulnerable, and they are not disadvantaged in sharing development benefits and opportunities resulting from the project.
- To utilize national environmental and social institutions, systems, laws, regulations and procedures in the assessment, development and implementation of projects, whenever appropriate.
- To promote improved environmental and social performance, in ways which recognize and enhance Borrower capacity.

These objectives are being met through this ESIA study being carried out by BET on behalf of the MOW/GOB.

3.4.2 Environmental and Social Standard 2: Labour and Working Conditions

This Standard recognizes the importance of employment creation and income generation in the pursuit of poverty reduction and inclusive economic growth. It expects that MOW/GOB and their contractors will promote sound worker-management relationships and enhance the development benefits of the project by treating workers in the project fairly and providing safe and healthy working conditions.

The objectives of this Standard are:

- To promote safety and health at work.
- To promote the fair treatment, non-discrimination and equal opportunity of project workers.
- To protect project workers, including vulnerable workers such as women, persons with disabilities, and migrant workers, contracted workers, community workers, and primary supply workers, as appropriate.
- To prevent the use of all forms of forced labour and child labour.
- To support the principles of freedom of association and collective bargaining of project workers in a manner consistent with national law.
- To provide project workers with accessible means to raise workplace concerns.

The objectives relevant to this project will be met through compliance with Belize's Labour Act and Regulations, ILO Convention Act, Occupational Safety and Health Bill, Contracts Act, Social Security Act, Protection against Sexual Harassment Act and Regulations, and Workmen's Compensation Act.

3.4.3 Environmental and Social Standard 3: Resource Efficiency and Pollution Prevention and Management

This Standard recognizes that economic activity and urbanization often generate pollution to air, water, and land, and consume finite resources that may threaten people, ecosystem services, and the environment at the local, regional, and global levels. The current and projected atmospheric concentration of greenhouse gases (GHG) threatens the welfare of current and future generations. At the same time, more efficient and effective resource use, pollution prevention and GHG emission avoidance, and mitigation technologies and practices have become more accessible and achievable.

The objectives of the Standard are

- to promote the sustainable use of resources, including energy, water and raw materials;
- to avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities;
- to avoid or minimize project-related emissions of short and long-lived climate pollutants;
- to avoid or minimize generation of hazardous and non-hazardous waste;
- to minimize and manage the risks and impacts associated with pesticide use.

The objectives relevant to this project will be met through compliance with Belize's Environmental Protection Pollution Regulations, Environmental Protection Effluent Limitations Regulations, and Environmental Protection Hazardous Waste Regulations.

3.4.4 Environmental and Social Standard 4: Community Health and Safety

This Standard recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts. In addition, communities that are already subjected to impacts from climate change may also experience an acceleration or intensification of impacts due to project activities.

This Standard addresses the health, safety, and security risks and impacts on project-affected communities and the corresponding responsibility of MOW/GOB to avoid or minimize such risks and impacts, with particular attention to people who, because of their particular circumstances, may be vulnerable.

The objectives of this Standard are:

- To anticipate and avoid adverse impacts on the health and safety of project-affected communities during the project life-cycle from both routine and non-routine circumstances.

- To promote quality and safety, and considerations relating to climate change, in the design and construction of infrastructure, including dams.

- To avoid or minimize community exposure to project-related traffic and road safety risks, diseases and hazardous materials.

- To have in place effective measures to address emergency events.

- To ensure that the safeguarding of personnel and property is carried out in a manner that avoids or minimizes risks to the project-affected communities.

The objectives relevant to this project will be met by compliance with Belize's Public Health Act and Regulations, Family and Children's Act and Regulations, Village Council Act and Regulations, Dangerous Goods Act, Property Protection (Fire) Act, Disaster Preparedness and Response Act, Fire (Negligent Use of) Act, Nuisances Act, Intoxicating Liquor Licensing Act, Public Roads Act, and Motor Vehicle and Road Traffic Act; and by compliance with the ESMP developed within this EISA study.

3.4.5 Environmental and Social Standard 5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement

This Standard recognizes that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons. Project-related land acquisition or restrictions on land use may cause physical displacement (relocation, loss of residential land or loss of shelter), economic displacement (loss of land, assets or access to assets, leading to loss of income sources or other means of livelihood), or both. The term "involuntary resettlement" refers to these impacts. Resettlement is considered involuntary when affected persons or communities do not have the right to refuse land acquisition or restrictions on land use that result in displacement.

The objectives of this Standard are:

- To avoid involuntary resettlement or, when unavoidable, minimize involuntary resettlement by exploring project design alternatives.

- To avoid forced eviction.

- To mitigate unavoidable adverse social and economic impacts from land acquisition or restrictions on land use by: (a) providing timely compensation for loss of assets at replacement cost and (b) assisting displaced persons in their efforts to improve, or at least restore, their livelihoods and living standards, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.

- To improve living conditions of poor or vulnerable persons who are physically displaced, through provision of adequate housing, access to services and facilities, and security of tenure.

- To conceive and execute resettlement activities as sustainable development programs, providing sufficient investment resources to enable displaced persons to benefit directly from the project, as the nature of the project may warrant.

- To ensure that resettlement activities are planned and implemented with appropriate disclosure of information, meaningful consultation, and the informed participation of those affected.

The objectives relevant to this project will be met by compliance with the Land Acquisition (Public Purposes) Act and in particular the third objective of this Standard in relation to the persons who are presently encroaching on the road reserve of the PGH between miles 8.5 to 24.5, in order to mitigate unavoidable adverse social and economic impacts when they are removed by: (a) providing timely compensation for loss of assets at replacement cost and (b) assisting displaced persons in their efforts to improve, or at least restore, their livelihoods and living standards, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.

3.4.6 Environmental and Social Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources

This Standard recognizes that protecting and conserving biodiversity and sustainably managing living natural resources are fundamental to sustainable development. Biodiversity is defined as the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems. Biodiversity often underpins ecosystem services valued by humans. Impacts on biodiversity can therefore often adversely affect the delivery of ecosystem services.

This Standard recognizes the importance of maintaining core ecological functions of habitats, including forests, and the biodiversity they support. Habitat is defined as a terrestrial, freshwater, or marine geographical unit or airway that supports assemblages of living organisms and their interactions with the non-living environment. All habitats support complexities of living organisms and vary in terms of species diversity, abundance, and importance.

This Standard also addresses sustainable management of primary production and harvesting of living natural resources.

The objectives of this Standard are:

- To protect and conserve biodiversity and habitats.
- To apply the mitigation hierarchy and the precautionary approach in the design and implementation of projects that could have an impact on biodiversity.
- To promote the sustainable management of living natural resources.
- To support livelihoods of local communities, including Indigenous Peoples, and inclusive economic development, through the adoption of practices that integrate conservation needs and development priorities.

The relevant objectives of this Standard will be met through compliance with Fisheries Act and Regulations Forests Act and Regulations, National Integrated Water Resources Act, Wildlife Protection Act and Regulations, National Protected Areas System Act, and Protected Areas Conservation Trust Act; and through compliance with the ESMP developed within this ESIA study.

3.4.7 Environmental and Social Standard 8: Cultural Heritage

This Standard recognizes that cultural heritage provides continuity in tangible and intangible forms between the past, present and future. People identify with cultural heritage as a reflection and expression of their constantly evolving values, beliefs, knowledge, and traditions. Cultural heritage, in its many manifestations, is important as a source of valuable scientific and historical information, as an economic and social asset for development, and as an integral part of people's cultural identity and practice. This Standard sets out measures designed to protect cultural heritage throughout the project life-cycle.

The objectives of this Standard are:

- To protect cultural heritage from the adverse impacts of project activities and support its preservation.
- To address cultural heritage as an integral aspect of sustainable development.
- To promote meaningful consultation with stakeholders regarding cultural heritage.
- To promote the equitable sharing of benefits from the use of cultural heritage.

The relevant objectives of this Standard will be met through compliance with the National Institute of Culture and History Act and through compliance with the ESMP developed within this ESMP.

3.4.8 Environmental and Social Standard 10: Stakeholder Engagement and Information Disclosure

This Standard recognizes the importance of open and transparent engagement between MOW/GOB and project stakeholders as an essential element of good international practice. Effective stakeholder engagement can improve the environmental and social sustainability of projects, enhance project acceptance, and make a significant contribution to successful project design and implementation.

Stakeholder engagement is an inclusive process conducted throughout the project life-cycle. Where properly designed and implemented, it supports the development of strong, constructive, and responsive relationships that are important for successful management of a project's environmental and social risks. Stakeholder engagement is most effective when initiated at an early stage of the project development process, and is an integral part of early project decisions and the assessment, management and monitoring of the project's environmental and social risks and impacts.

The objectives of this Standard are:

- To establish a systematic approach to stakeholder engagement that will help MOW/GOB identify stakeholders and build and maintain a constructive relationship with them, in particular project affected parties.

- To assess the level of stakeholder interest and support for the project and to enable stakeholders' views to be taken into account in project design and environmental and social performance.

- To promote and provide means for effective and inclusive engagement with project-affected parties throughout the project life-cycle on issues that could potentially affect them.

- To ensure that appropriate project information on environmental and social risks and impacts is disclosed to stakeholders in a timely, understandable, accessible, and appropriate manner and format.

- To provide project-affected parties with accessible and inclusive means to raise issues and grievances, and allow MOW/GOB to respond to and manage such grievances.

The objectives of this Standard will be met through compliance with the Freedom of Information Act, the Environmental Impact Assessment Regulations and the ESMP developed within this ESIA.

CHAPTER 4:ENVIRONMENTAL SETTINGS

4.1 Geology of Study Area

4.1.1 Regional Geology

Belize can be divided into three major structural entities or geological provinces (Purdy, Gischler and Lomando, 2003); (1) the Corozal Basin in the north, representing an eastern continuation of the northern Guatemala Peten Basin; (2) the central Maya Mountain Block, comprised primarily of igneous and metamorphic rocks; and (3) the Belize Basin to the south, it borders the Maya Mountain block offshore to the east and onshore and offshore to the south, it is a continuation of the southern part of the Peten Basin (Prasada and Ramananthan, 1988).

The Corozal Basin is an extension of the north Peten Basin which is an extended continental shelf deposit comprising of undifferentiated limestones and dolomites of Cretaceous age (Barton Creek, Yalbac and Hillbank Formations); bedded or massive limestones and marls that exhibit some karstification; limestones of Early Tertiary age (El Cayo Group and Doubloon Bank Formations) which are primarily lagoonal limestones with some dolomites and minor marls; marls and limestones of Late Tertiary/ Miocene-Pliocene age (Orange Walk Group), deposits exhibit fossils of oysters, gastropods and coral fragments; clays of Late Tertiary/ Miocene-Pliocene age (Red Bank Group), red to grey mottled clays with inclusions of chert a few fossilerferous beds and some sands; alluvial deposits of Quaternary age, quartz sands derived from erosion of the Maya Mountains, river terraces, silts and clays with some conglomerate clasts (Cornec, 2010) (see Figure 4.1). An extensive part of the deposition in the Corozal Basin was done in a restricted shallow lagoon environment with depositional episodes being done in a passive environment.

4.1.2 Geology of the Study Area

The study area lies in the lower plain of Corozal Basin which is the sections dominated by the shallow lagoon sands and clays, there are some occurrences of marls and limestones (see Figure 4.1).The surface geology within the study area is covered predominately Quaternary terrigenous derived sediments eroded and deposited primarily from a Maya Mountain source; quartz sands (pine ridge sands), silts and clays interspersed with some shallow lagoonal calcareous

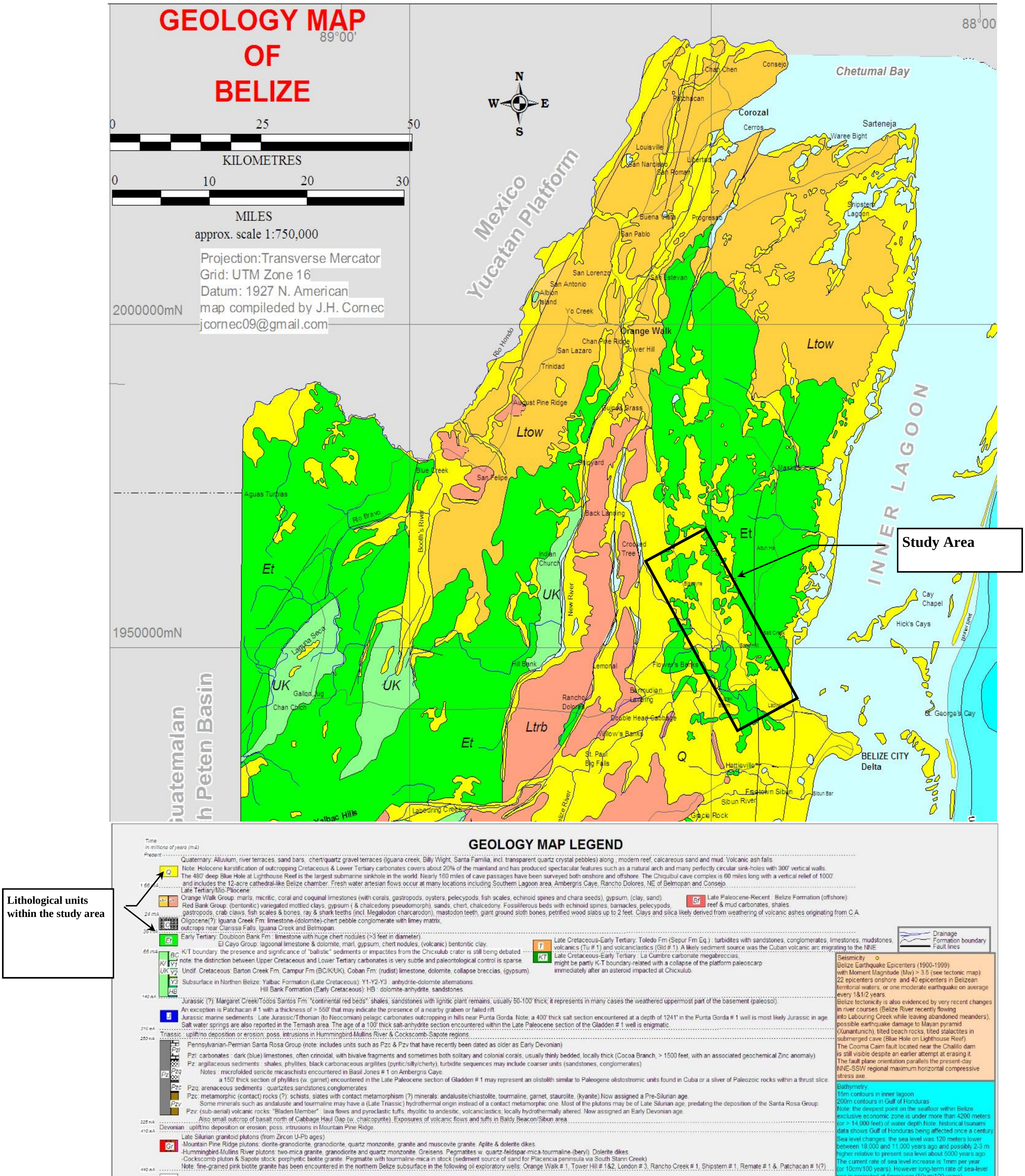


Figure 4.1: Geology Map of Belize (Extract). Source: Cornec Jean 2010.

derivatives, marls and thinly bedded limestones, the marls typically tend to have limestone boulders and the clays tend to have chert inclusions which may be viewed as a residual deposit or soils, conglomeratic nodules of manganese and ferruginous pebbles and cobbles are often present (see Figures 4.2 and 4.3).

The subsurface geology is late to early Tertiary composed of either the Red Bank or El Cayo group (Cornec Jean, 2010) of benthonic red variegated mottled clays and sandy clays which is believed to overlaying Mesozoic carbonate rocks (Cornec Jean, 2010. Dixon, 1975. Flores, 1952). The limestone bedrock has been described at depths ranging from outcropping (BET Field visit 2017) to encountered depths of 7ft to about 42ft (Dixon, 1975, Flores, 1952), as also observed in the boreholes near Mexico Creek bridge, limestone encountered at 74ft on the north side and 54ft of the south side (MOW Sub soil Inv. Mexico Creek Bridge, 2017), these reports all speaks to the undulating nature of the limestone bedrock.

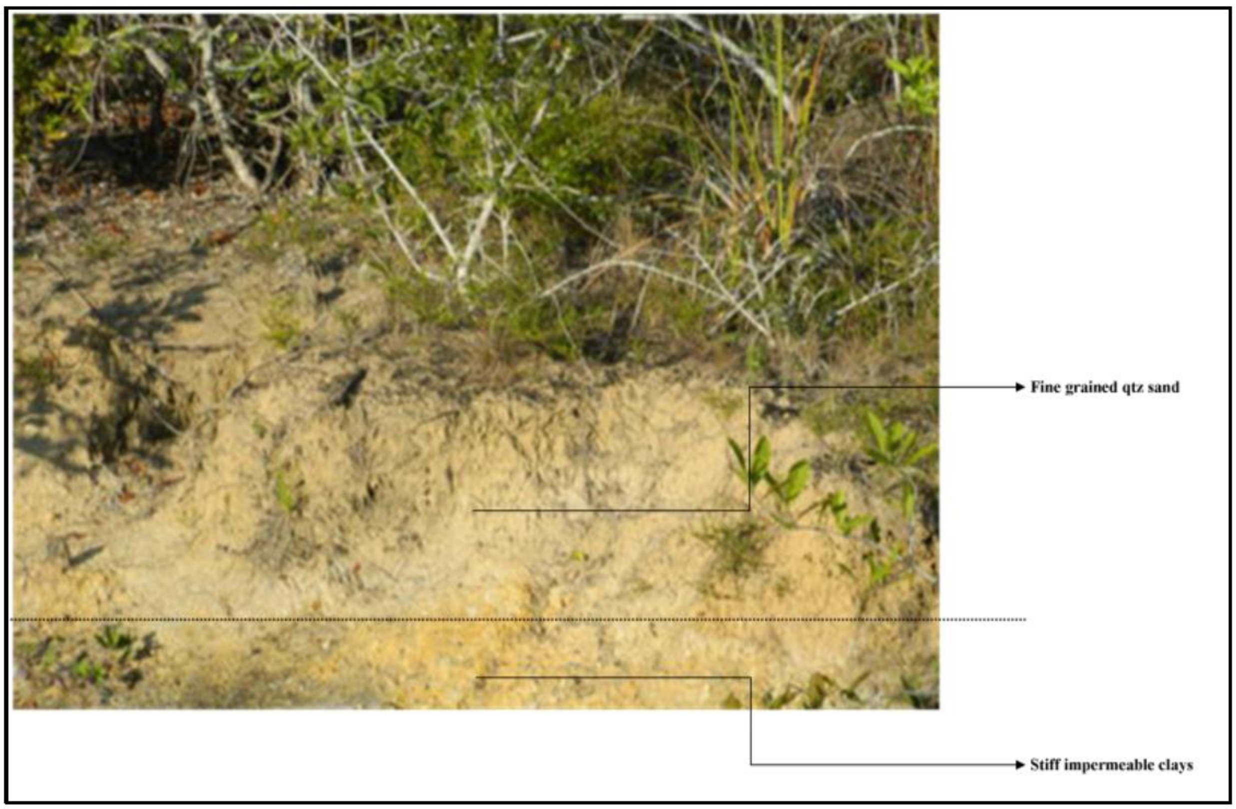


Figure 4.2: Typical surface exposure.

Figure 4.3: Showing typical surface outcrops of (a) clays, (b) sands and (c) marls.

4.1.3 Soil Structure and Classification

The study area falls within the Northern Coastal Plain (King et al. 1991) primarily in the Tok Plain (flat plain/ redeposited alluvial wash comprised of Tok /Haciappina soils) with some sections of the study area exhibiting Pueltan Plain soils (flat saline plain with Savannah soils) and some sections of the Corozal Saline Swamps soils (savannah/mangrove with Ycacos soil type).

The Tok Plain has been described as having very little agriculture possibility ranked as grade 4 soils; soils with chances for financial success being marginal even with skilled management and high inputs, with a low conservation value of 3 (marginal conservation value) with limitations of poor nutrient content, drainage concerns and moisture retention issues, the outlined use is for aquaculture or pasture. The drainage and marsh conditions of these soils must be factored into the design parameters for the road upgrade.

The test pits done (BET Field investigations 2012, see Figure 4.4) are indicative of the situation outlined above and are consistent with the descriptions given in the Land Suitability/Land Systems Analysis (King et al. 1991) as they all show a graduation of little to no topsoil <1ft, to a sand which grades to sandy clay which moves rapidly into a tight impermeable red to grey mottled clay, with the test pits showing the undulating marl with limestone boulder layer near surface; encountered <9ft from surface in the savannah area, which further confirms the underlying unconformable nature of the limestones.

TEST PIT # 1		
Location: E0358440 N1943184 undisturbed savannah		
Lithology	Depth in/ft	Description
1	8"	Topsoil; organic rich, black topsoil
2	2	red to grey mottled clay with some sand inclusion
3	14	Red to Grey Mottled clay tight impermeable
4	20	Red tight impermeabl clays with limestone boulders and some marl inclusions
5	>21	Marl with limestone boulders limstone boulders are fine grained crystalline marl is grading to limestone, assumed bedrock

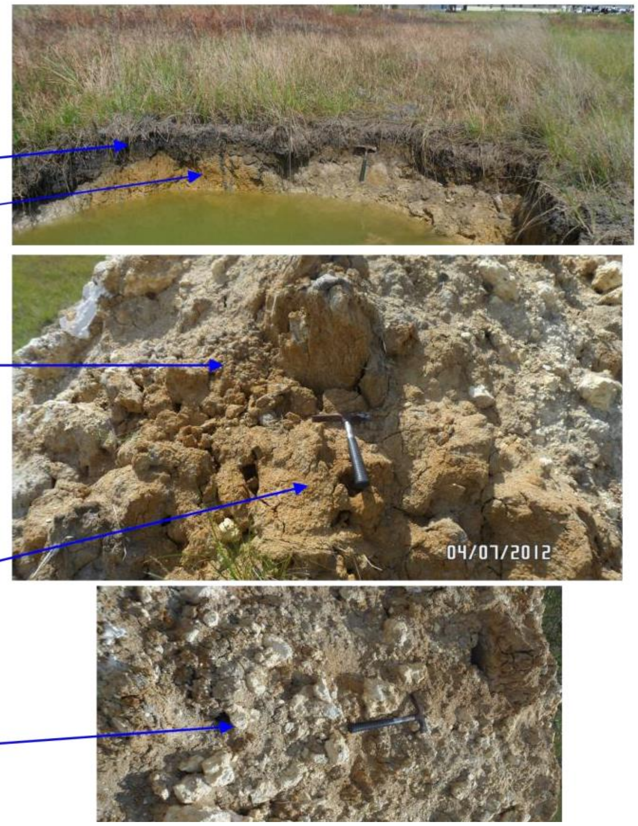


Figure 4.4a: Test Pit 1- Typical soil profile within the Tok Plain.

TEST PIT # 2		
Location: E0358524 N1943439 undisturbed savannah		
Lithology	Depth in/ft	Description
1	6"	sandy clay, red clay qtz sand
1	4	red to grey mottled clay with some sand inclusion
2	9	Red to Grey Mottled clay with limstone boulders tight impermeable
3	>9	Marl with limestone boulders marl is grading to limestone, assumed bedrock

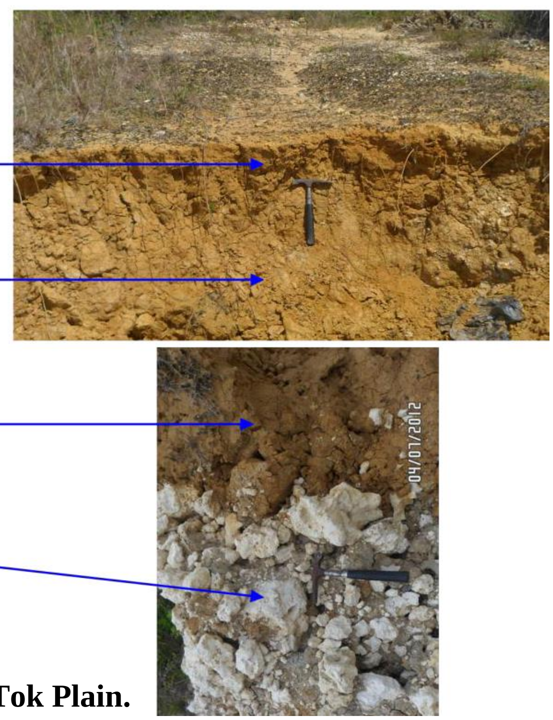


Figure 4.4b: Test Pit 2- Typical soil profile within the Tok Plain.

4.1.4 Tectonics and Seismicity

The Belize Basin exhibits a NNE-SSW trending fault system of normal faults that parallel the structural highs, this fault system is considered tectonically inactive. Within the study area there are two splays of the transpressional faults (see Figure 4.5) that parallel the Shipstern Ridge (Purdy 2000) structural high. There was no evidence of any structural expressions of the faulting within the study area. Regionally the alignment of the lagoons in close proximity to the study area, Crooked Tree Lagoon, New River Lagoon, etc, are fault oriented.

The MOW reported that with the 2009 Honduras earthquake which occurred on May 28, 2009 with a moment magnitude of 7.3 and a maximum Mercalli intensity of VII (*Very strong*), Belize had one bridge knocked off its support in the Village of Rancho Dolores, another in Lemonal Village suffered damage (both in the Belize district) as well as the More Tomorrow Bridge, Cayo District. Taking this into consideration, the project area has three bridges that can be affected by earthquakes, namely the Mexico Creek Bridge on the PGH carriage way (WGS84=Lat. 17.65553 Lon. -88.39571), Grace Bank/Davis Bank wooden bridge (WGS84=Lat. 17.64985 Lon. -88.398791) to the south of the PGH and the newly installed May Pen bridge (WGS84=Lat. 17.66002 Lon. -88.442733) to the west of the PGH. The latter two are within the buffer area of the project site.

4.1.5 Geological Risks/Evaluation

The study area is in a tectonically inactive region although it has two splays of the NNE-SSW fault system within the study area, as it is inactive it has very little risk in terms of seismic impact. The low relief with an elevation difference of +/- 20m from the SE (Lords Bank junction) to NW (Crooked Tree junction) alignment of the road section reduces the risk or potential of slumping or land slip.

However, due to the presence of the sands in the marsh setting with high organic content underlain by the impermeable clays that create a scenario of a state of semi-permanent inundation, allow for land subsidence and sinking. This is exhibited in the sections of the road primarily between Sand Hill and Biscayne where there are numerous dips in the road alignment due to partial subsidence of the road base. As the entire zone within these marsh areas has similar

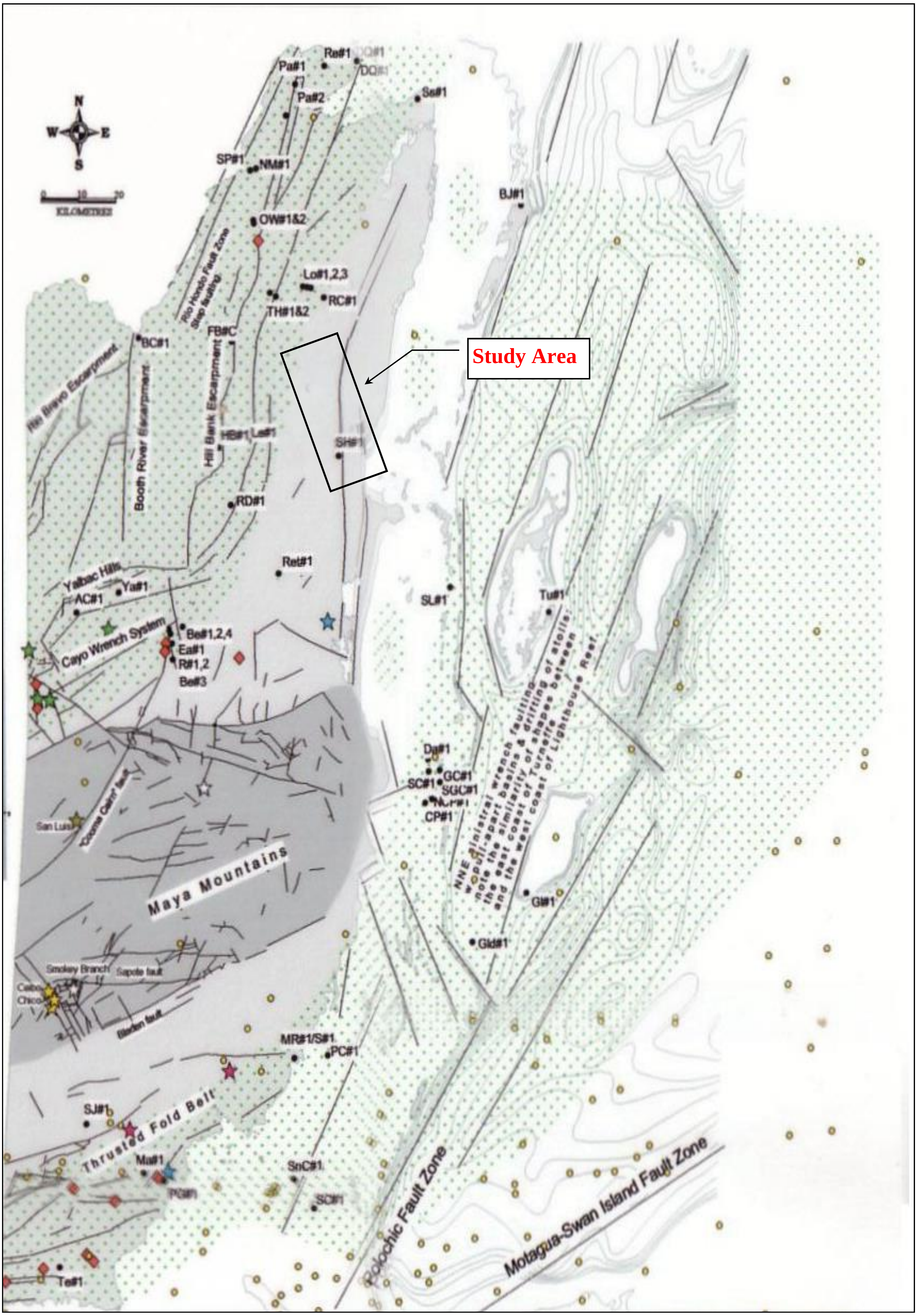


Figure 4.5: Tectonic Map of Belize, extract from Cornec, 2010, Geology Map of Belize. (Source: Purdy, 1975).

characteristic of low load bearing capabilities it allows for plastic deformation along the entire road carriage way creating a sinusoidal horizontal road alignment. This issue of subsidence needs to be evaluated and factored into the engineering design of the road upgrade.

4.1.6 Quarries/Evaluated Quarries

4.1.6.1 Identification of Sites

- Compilation of existing private and MOW sites and abandoned quarry sites undertaken.
- Evaluation of material suitability for the required needs of the project, i.e. increasing elevation above current ground levels, material for base, sub-base, and wear coarse.
- Ranking and weighting against selection criteria was done.
- Due to the absence of hard rock within the immediate project area and extended area was used for identification of known and potential quarries.

In field site assessment of each potential site was conducted to examine suitability for adequate material supply as well as site specific conditions.

4.1.6.2 Evaluated Quarries

Data from the Mining Unit, Ministry of Natural Resources, and data from the Ministry of Works (MOW) was used to compile a list of the existing quarries, both within the immediate project area and outside of the project. A total of six quarries was evaluated, four MOW sites and two private, three within the project area and three outside of the project area (Table 4.1 and Figure 4.6).

Table 4.1: BET identification of quarries.

#	Datum NAD 27		Location	Remarks
	Eastings	Northings		
1	322065	2005883	Albion Island, Orange Walk	Private Quarry, Demars Construction (note two other smaller quarries are in the Albion island area). Limestone and marl.
2	361746	1977946	Bomba, Belize District	MOW quarry Limestone and marl
3	357142	1957288	Rockstone Pond, Belize District	MOW quarry (abandoned) Limestone and marl
4	345966	1957142	Biscayne, Belize District	MOW quarry Marl
5	347986	1956587	Biscayne, Belize District	MOW quarry (abandoned) Marl
6	346228	1922868	Rockville, Belize District	Private Quarry, National Aggregates (Nat'l Agg.) (Note several other un-quarried hillocks are in the area). Limestone and marl.

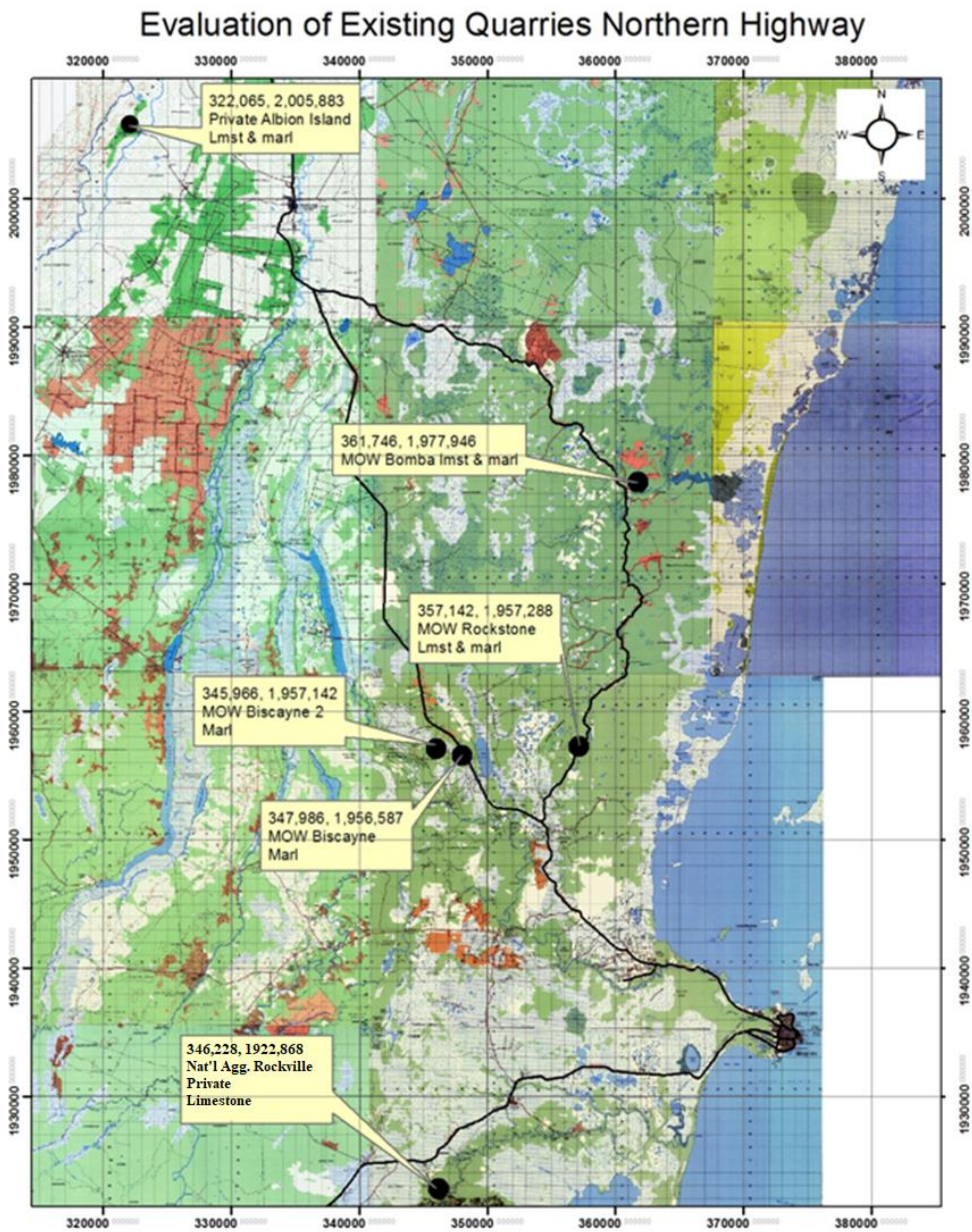


Figure 4.6: Evaluation of existing and abandoned quarries and areas of potential. (Datum NADS 27).

4.2 Topography

The Northern Coastal Plain is part of the large, flat, crustal Yucatan Platform underlying the southern Yucatan, north-eastern Guatemala, and northern Belize. This platform is overlain by marine sedimentary rocks composed of the calcium carbonate shells, mostly from microscopic marine organisms, accumulating when this present-day landscape was beneath a shallow sea (late Mesozoic and early Cenozoic Eras, about 160 to 56 million years ago). These limestone layers are two kilometres thick in places, and besides calcium carbonate, are made up of deposits of gypsum, other evaporite minerals, dolomite, chert nodules, and deposits of silica dioxide. Evidence of this material was observed at the falls or rapids in Black Creek and the Belize River near Grace Bank during recent field operations conducted by BET.

Figures 4.7 and 4.8 are DEM map (1:150,000) of lower Belize River sub-catchment with 1-meter LiDAR contours (derived from SRTM 30 m for canopy level) for the Vista del Mar/Ladyville area and the Mexico Creek Bridge area. DOS maps for other sections of PGH project zone are included in Annex V.

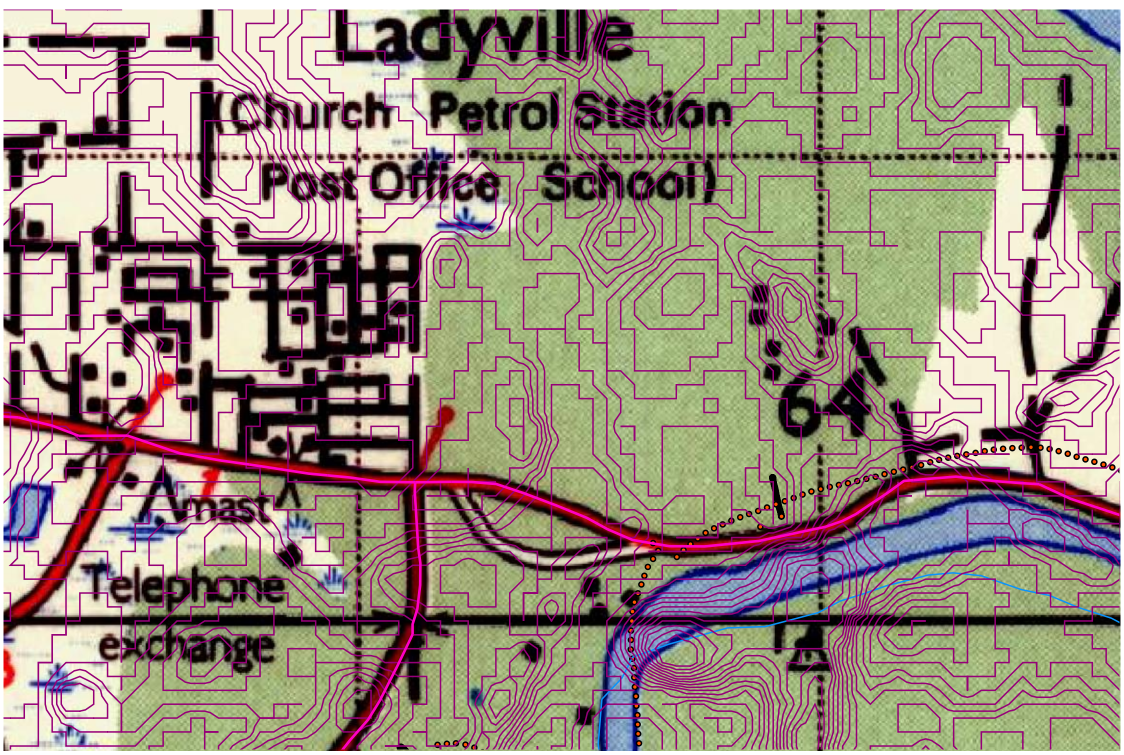


Figure 4.7: DEM with 1-m LiDAR canopy level contours around Ladyville-Vista del Mar.

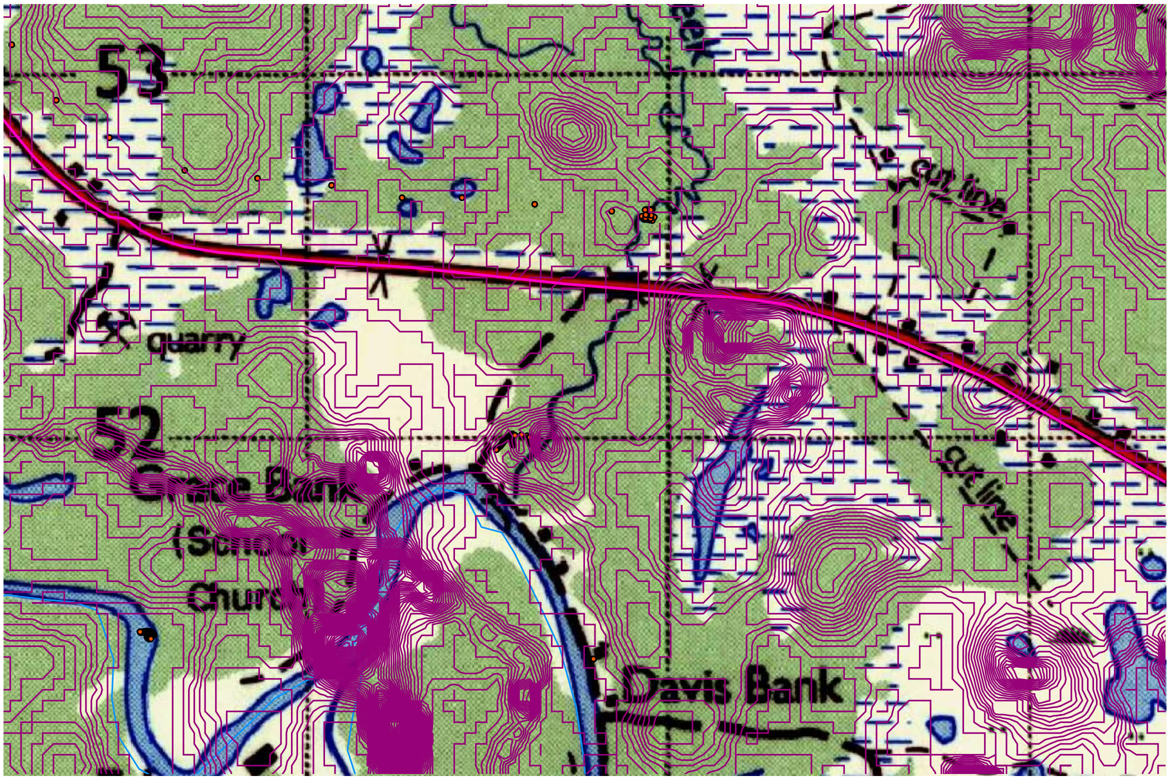


Figure 4.8: DEM with 1-m LiDAR canopy level contours around Mexico Creek Bridge and Grace Bank.

Elevations indicated below were obtained from the draft topographic survey received from Golder. The benchmark used to obtain the elevations was not identified.

The road centreline elevation (road profile station 0+040) in the Vista del Mar junction with the GPH is 1.975m and at the airport road junction with the GPH (road profile station 0+660) is 2.247m

At the Sandhill-Old Northern Highway junction the elevation (road profile station 17+060) is 8.212m at the Mexico Creek Bridge (road profile station 19+640) is 7.201m, and around Gardenia along the highway the elevation   ranged from 6.973m(road profile station 19+700) to 6.943m (road profile station 20+700).

The lower Belize River sub catchment that encompasses Miles 8.5 – 24.5 of the PGH slated for rehabilitation, is generally flat and slightly undulating with low lying areas which are subject to fresh water ponding and floods during the rainy season.

Vista del Mar/Ladyville

A natural creek runs from inside the Airport southward to Vista del Mar area. Generally the drainage is in poor condition, urban expansion continues in this general area and hence this section of the Highway is highly prone to floods.

Mexico Creek Bridge/Davis Bank

This area, especially the along the access road to Grace Bank is prone to flood in extreme storm events. The section of the Highway from Mexico Creek Bridge to Gardenia village where the PGH traverses the natural wetland is also vulnerable to flooding during intense and prolonged rainfall events. Clearing the Mexico Creek and improving the drainage in this area would minimize the impacts of future floods to the PGH. Also, the riparian forests along the Belize River and tributaries must be managed and protected, so that they provide the environmental service of stabilizing the stream banks, regulate storm water runoff, reduce erosion and sedimentation, and provide a natural habitat for wildlife

Crooked Tree Lagoon Hydraulic System

The Crooked Tree Lagoons system is critical in the drainage dynamics of the Greater Belize River Basin, including the Belize River Valley. Its water impounding characteristics and retention capacity are key to understanding the hydraulic equilibrium of the area and the effects on the PGH network. Both the "Agriculture Sector: Belize Rural North Action Plan and Implementation Strategy Report" (February, 2013) and TYPSA, "Global Study to Propose Specific Interventions to Reduce the Belizean Road Network Vulnerability to Flooding Events" (February, 2010), conclude that excessive surface runoff from as far as Guatemala and the Cayo District, eventually drains into the Crooked Tree catchment area. The meandering of surface water backs up the Southern Lagoon and Crooked Tree Lagoon, which in turn saturate the local wetlands, and even direct water northwards into the New River wetlands.

The hydraulics of the Crooked Tree Lagoon system is complex primarily because of the dynamics of the surface flow during extreme flood events. It has been recorded that the uniform contours of the catchment area (small gradient) provides for the movement of runoff which can move in a variety of ways depending on the prevailing hydraulic conditions. The lack of adequate historical, hydro-meteorological data and high resolution maps, precludes rigorous analysis and modelling of different flooding scenarios for the Crooked Tree Lagoon system sub-catchment.

Crooked Tree is an island surrounded by the Crooked Tree Lagoon, sometimes called the Northern Lagoon. The access causeway has two bridges and two culverts that help circulate the flow in the lagoon, but in extreme rainfall events, these hydraulic structures do not have the capacity to facilitate the free flow of rising flood waters, so the access road itself becomes partially inundated, and villagers have to use boats as the only means of transportation to and from Crooked Tree. Information to be derived from the feasibility study and the preparation of designs to upgrade the Crooked Tree Road and Causeway can be used in conjunction with this study to better understand the prevailing hydraulic conditions of the entire wetland system affecting the PGH.

Figure 4.9 are views of the Northern Lagoon at Crooked Tree and the western causeway.

Figure 4.9: (Left) Crooked Tree Northern Lagoon and (Right) View of the causeway to Crooked Tree Village.

4.3 Land Use

The first section of the study area, beginning at the junction of the Vista del Mar, is dominated by the heavily urbanized and developed communities of Ladyville and Lords Bank and the smaller Los Lagos, and includes the airport complex, a piece of the coastal area and the Inner Channel, a coastal marina with dredged canals, several sand mining sites, a small shrimp farm, and the large inactive and degraded shrimp farm and factory developed by Nova, Inc. Much of this urbanized and industrialized area has been built within savannah lands that are largely wetlands. This urban area includes many lagoons, most of which have been cleared of trees, human-built lagoons (some serving as wastewater treatment lagoons), aquaculture ponds, canals and many acres of seasonally dried to inundated savannah ponds. Many of the lots and most of the road beds have been filled and built up, effectively reducing wetland floodwater storage space and damming surface water flow in the local area. The canals constructed for aquaculture water intake and wastewater discharge, draining lower areas of urbanized space, and the creation of marina space act to lower the local water table, affecting dry season groundwater levels.

The northern end of the project area is largely rural, including a few small communities (Lord's Bank, Sandhill, Gardenia and the beginning of Biscayne), scattered houses along several side roads, and a few small agricultural plots (row crops, small orchards, possible pasture). The Biscayne area is made up of evergreen seasonal broadleaf lowland forest over calcareous soils, evergreen seasonal swamp forest, and a significant amount of agriculture and private land. A large section of Mexico Lagoon/Jones Lagoon, part of the Crooked Tree Wildlife Sanctuary occupies the north-eastern section of the project area. Overall the northern portion consists of large areas of relatively pristine savannah wetlands and lagoons, black water streams, riparian forests (especially along the Belize River), and upland forest areas.

4.4 Climate, Climate Variability and Climate Change

4.4.1 General Climate

Belize has a moist tropical climate with marked wet and dry seasons. A cool transition period separates the two main seasons, and extends from November through February, when incursions of cooler continental air mass and associated frontal systems push southwards into northern Central America and the western Caribbean.

In the wet season, mean monthly rainfall can be 150 to 400 mm, with highest rainfall totals in the south. In the dry season, most of the country receives less than 100 mm of rainfall per month. The coastline of Belize is also vulnerable to Atlantic tropical cyclones and hurricanes from July through to the end of October. Heavy rain falls accompanying these storms contribute a significant fraction towards the high wet season rainfall totals.

Figure 4.10 is the annual mean rainfall pattern for Belize. Annual mean rainfall in the Belize district and the first 50 miles of the PGH from Belize City is in the range of 60 – 100 inches (1,524 mm – 2,540 mm), as can be seen in Figure 4.10. The annual rainfall distribution is bi-modal, with peak rainfall in June and October.

Temperatures vary according to elevation, proximity to the coast, and the moderating effects of the northeast trade winds off the Caribbean. Average temperatures in the coastal regions range from 24° C in January to 27° C in July.

The southwest, interior region of the country tends to be a little cooler than regions in closer proximity to the coast. Inter-annual variations in climate in southern Central America are caused by the El Niño Southern Oscillation (ENSO). El Niño events bring relatively warm and dry conditions between June and August, and decreased frequencies of Atlantic tropical cyclones, whilst La Niña episodes bring colder and wetter conditions at that time of year, and more frequent than average tropical cyclones (McSweeny, *et al.*, 2012).

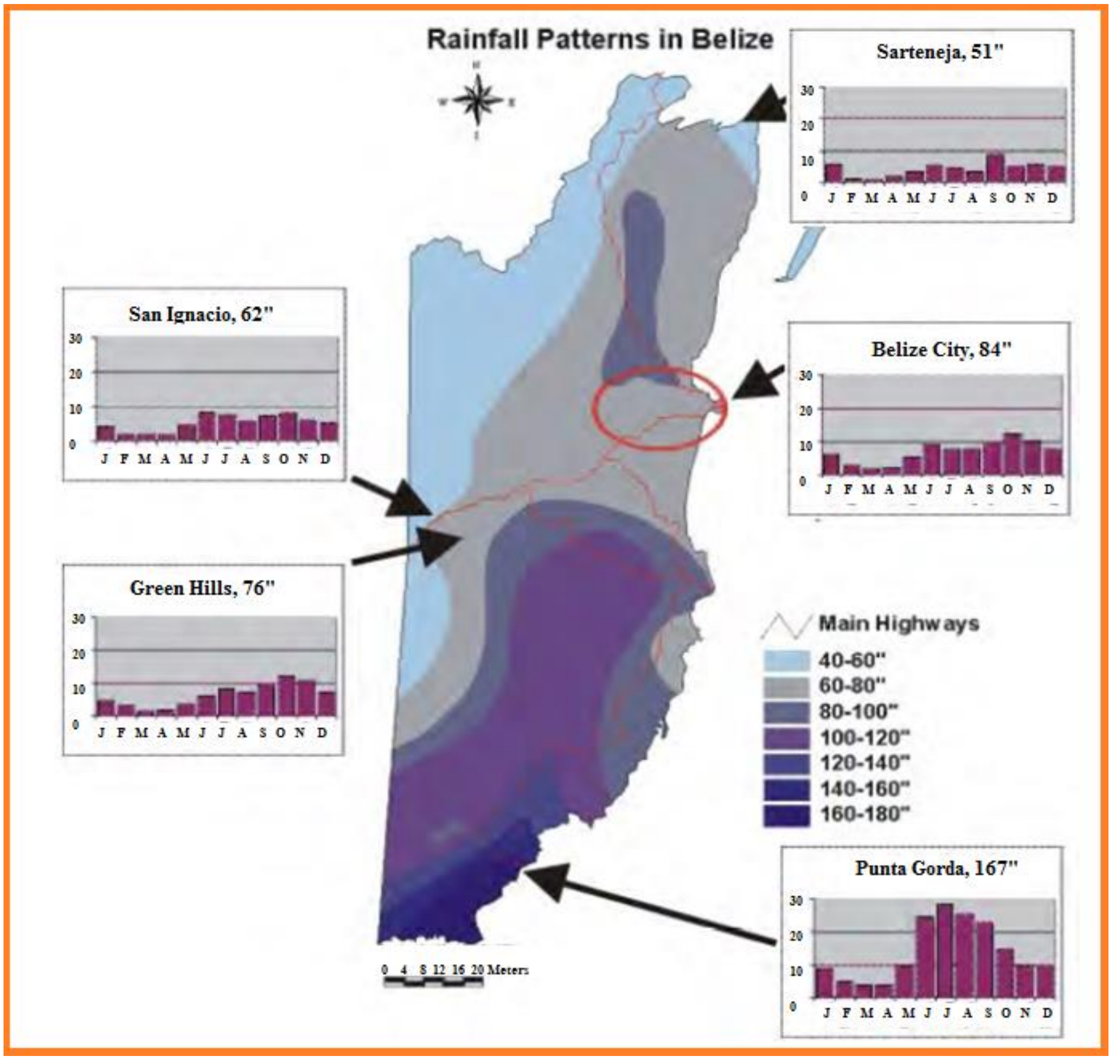


Figure 4.10: Mean Annual Rainfall for Belize.

Figure 4.11a and Figure 4.11b show probability values of monthly rainfall for the Philip Goldson Airport and Tower Hill, Belize Sugar Industry site, Orange Walk district, derived from historic monthly rainfall for the periods 1960 – 2010 and 1990 – 2010, respectively. Dependable rainfall (75 percentile) is about 50 to 75 mm in the Dry Season at the Airport, and about 300 to 350 mm in the wet season. The historic, daily extreme rainfall in excess of 400 mm occurred in the wet season from May to October at the Philip Goldson Airport, (Figure 4.11a). The very extreme daily rainfall of just over 1000 mm occurred in October, during the hurricane Keith (2000) event. At Tower Hill, the historic, daily extreme rainfall was 540 mm also in October 2000 (Figure 4.11a).

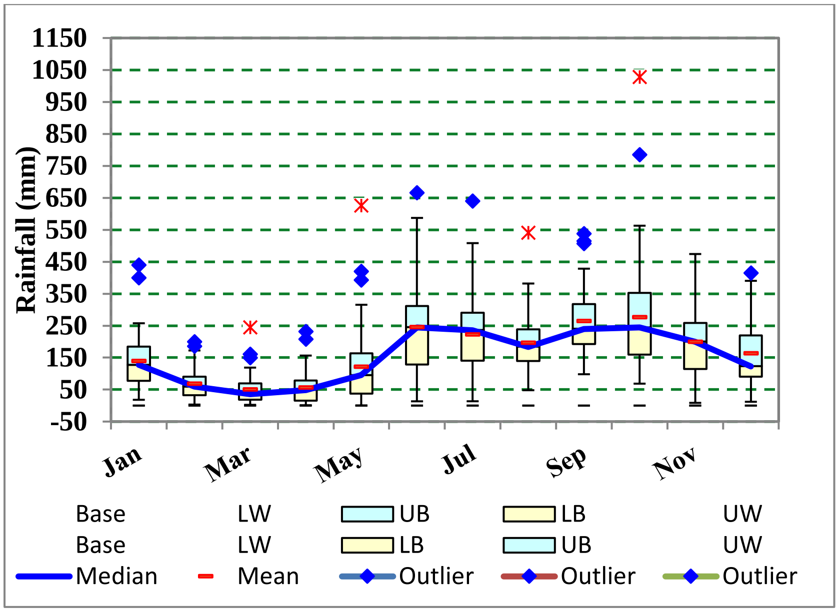


Figure 4.11a: Probability Values and Extreme Rainfall (mm) for Philip Goldson Airport for the Period 1960-2010.

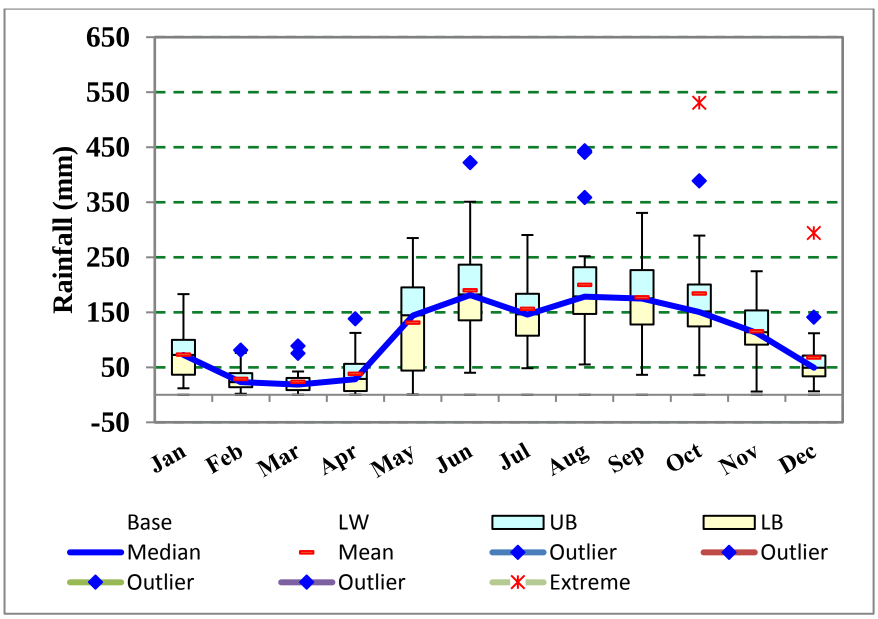


Figure 4.11b: Probability Values and Extreme Rainfall (mm) for Tower Hill, Orange Walk District for the Period 1990-2010.

The climate charts for the Philip Goldson Airport and Tower Hill (BSI/ASR) are presented in Figures 4.12a & b). The rainfall regime at both localities shows bi-modal characteristic, with peak rainfall in June/July and October, and a marked, but short dry spell in August (*maaga* season, or mid-summer drought). Monthly average temperature varies from near 25 °C in January to 28 °C in the May-September period at both localities (Figures 4.12a & b). Rainfall deficit period, precipitation – evapotranspiration (P – ETP) curve extends from February to the end of May at the Airport, and from January to end May at Tower Hill, indicative of a longer dry season in the North.

The representative rainfall station in the project zone is the Philip S.W. Goldson International Airport (PGIA). Table 4.2 shows the seasonal rainfall for key meteorological stations in the Greater Belize River Basin. The annual mean rainfall at the Philip Goldson Airport is 2000 mm or near 79 inches. The season with the highest rainfall falls within the months of September, October, and November totalling 737 mm or about 37% of the annual mean rainfall. It should be noted that the watersheds comprising the Greater Belize River Basin do not work in isolation of each other, but rather they are interconnected and work as a network of water bodies.

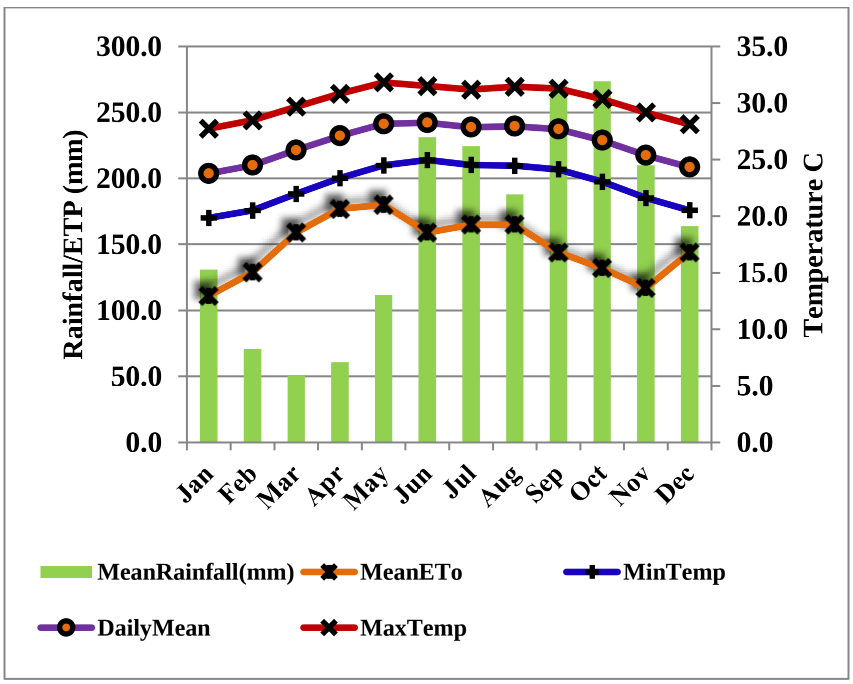


Figure 4.12a: Mean Monthly Rainfall, Evapotranspiration and Temperature for Philip Goldson Airport (Period 1970-2004).

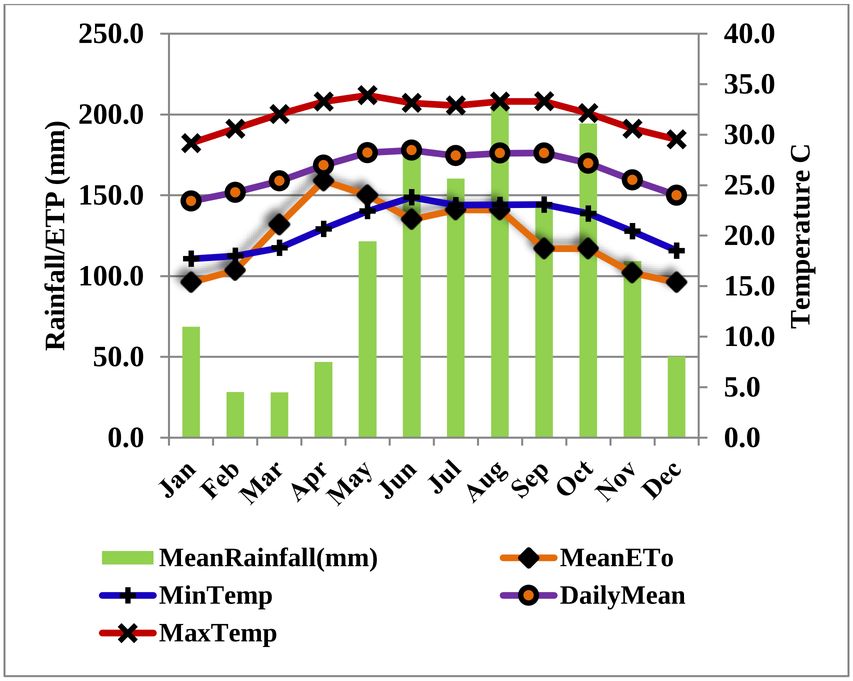


Figure 4.12b: Mean Monthly Rainfall, Evapotranspiration and Temperature for Tower Hill, BSI/ASR (Period 1970-2004).

Table 4.2: Historic seasonal rainfall at some key stations in the Greater Belize River Basin.

Key Stations	Mean Seasonal Rainfall (mm)				Annual Mean	Percent of Mean Annual Rainfall (%)			
	DJF	MAM	JJA	SON	(mm)	DJF	MAM	JJA	SON
PSWGIA	383.2	225.5	662.5	737.3	2008.5	19	11	33	37
Belmopan	370.2	173.1	806.8	669.8	2019.9	18	9	40	33
Central Farm	343.4	164.7	600.7	572.6	1681.5	20	10	36	34
Spanish Lookout	285.0	177.5	579.2	536.0	1578.0	18	11	37	34
Chaa Creek	220.3	183.6	250.3	533.9	1288.1	17	14	27	42
Barton Creek	280.4	151.1	505.4	557.1	1494.0	19	10	34	37
Mollejon	238.8	167.6	426.7	632.5	1465.6	16	11	29	43
Douglas D' Silva	307.3	215.9	520.7	706.1	1750.1	18	12	30	40

4.4.2 Surface Winds

The prevailing winds along the coast of Belize are predominantly out of the northeast, east, and southeast at about 5 – 15 knots, as can be observed from the historical mean, annual wind-rose chart (Figure 4.13a) for the Philip Goldson Airport. In the Belize City area and the project site the winds generally blow moderately from the east and southeast at about 8 – 18 knots during the dry season months of March, April, and May. From June through August the prevailing winds are out of the east at about 8 – 16 knots. During the cool transition months of October through early March incursions of cool, continental air masses and associated frontal boundaries (cold fronts) move across the Gulf of Mexico and spill into the north-western Caribbean, occasionally reaching the central Caribbean. The northerly winds associated with these cool air mass incursions are often gusty, generating turbulent seas and unfavourable condition for marine operations in exposed regions of Belize's coastal waters. Such events may persist for a day or two, but may also extend to 4 or 5 days during intense cold air outbreaks from the north.

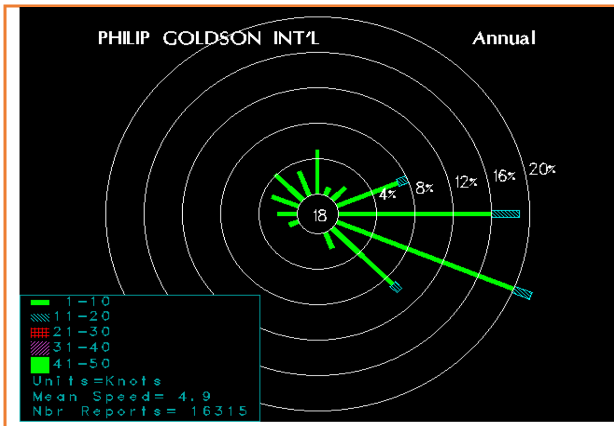


Figure 4.13a Mean annual wind-rose for the PGIA. (Source: BNMS[4]).

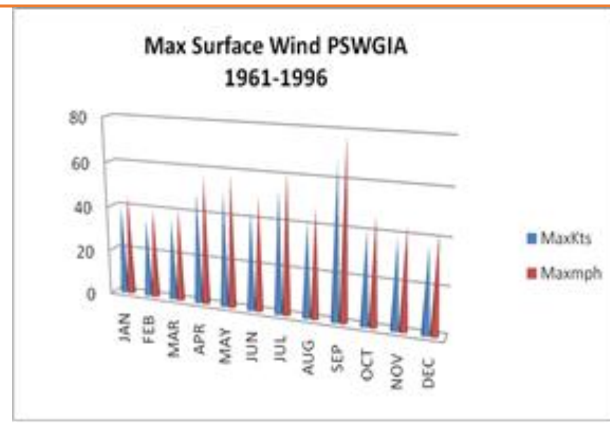


Figure 4.13b: Monthly maximum surface wind (kts and mph[5]) at PGIA. (Source: BNMS).

Historical extreme winds speed is associated with tropical cyclones and tropical disturbances that traverse the north-western Caribbean and affect the coastal zone of Belize. These events are more frequent during the hurricane season or summer months, but invariably are also associated with strong northerly airflow generated by cold air mass movement over the region during the cool transition period. Figure 4.13b is a graph showing records of historical daily maximum wind speeds at the Philip Goldson Airport for the period 1961 to 1996. As can be observed, September holds the record for the highest surface wind speed at the Airport with a value of 64 knots or 75 mph.

[4] National Meteorological Service
[5] kts = knots and mph = mile per hour

4.4.3 Tropical Cyclones and Hurricane Risks

Belize is prone to various hazards, including hurricanes, tropical storms, storm surges, floods, drought, and earthquakes. The country also has a high vulnerability to natural hazards as the large majority of its population and economic activity (mainly agriculture, tourism, and commerce) is concentrated along an exposed low lying coastal zone, as well as on the flood-prone banks of the main river systems. Figure 4.14 and Figure 4.15 are maps showing the tracks of historical tropical cyclones that have affected Belize.

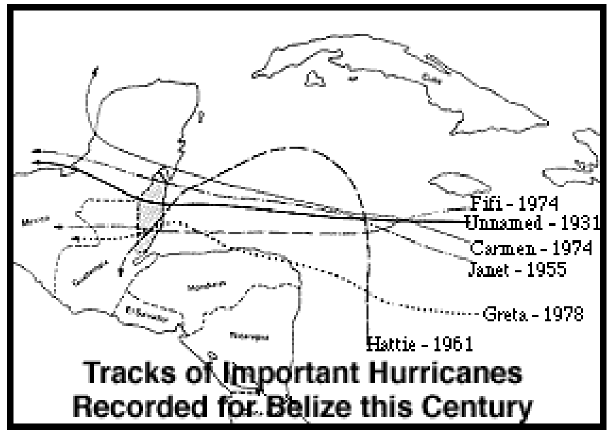


Figure 4.14: Tracks of Some Major Hurricanes over Belize during 1960-80.

As with any coastal plain development, the rehabilitated PGH will be prone to the hazards of future land-falling hurricanes over Belize. Updated analysis based on hurricane tracking maps and reports for the past three decades (1994-2014) showed that eight (8) hurricanes and four (4) tropical storms affected the country. Nine of these tropical cyclones impacted the northern Cayes and northern coastal areas, with torrential rainfall, storm surge and sustained, hurricane force winds, resulting in extensive beach erosions, infrastructural damage, and coastal flooding. The IPCC (2007) predicts that in a warmer climate, the frequency of more intense tropical cyclones in the major hurricane basins will be on the increase during the 21st century. Thus, designs of road infrastructures must consider the worst case scenarios, but at the same time resolve the pros and cons of increase exposure and vulnerability, and higher capital costs.

Specifically, during the period 1970 to 2010, hurricanes, tropical storms, storm surge, and floods affected more than 300,000 people, resulted in 69 deaths, and caused more than US $526 million in economic damage (GOB, 2010).

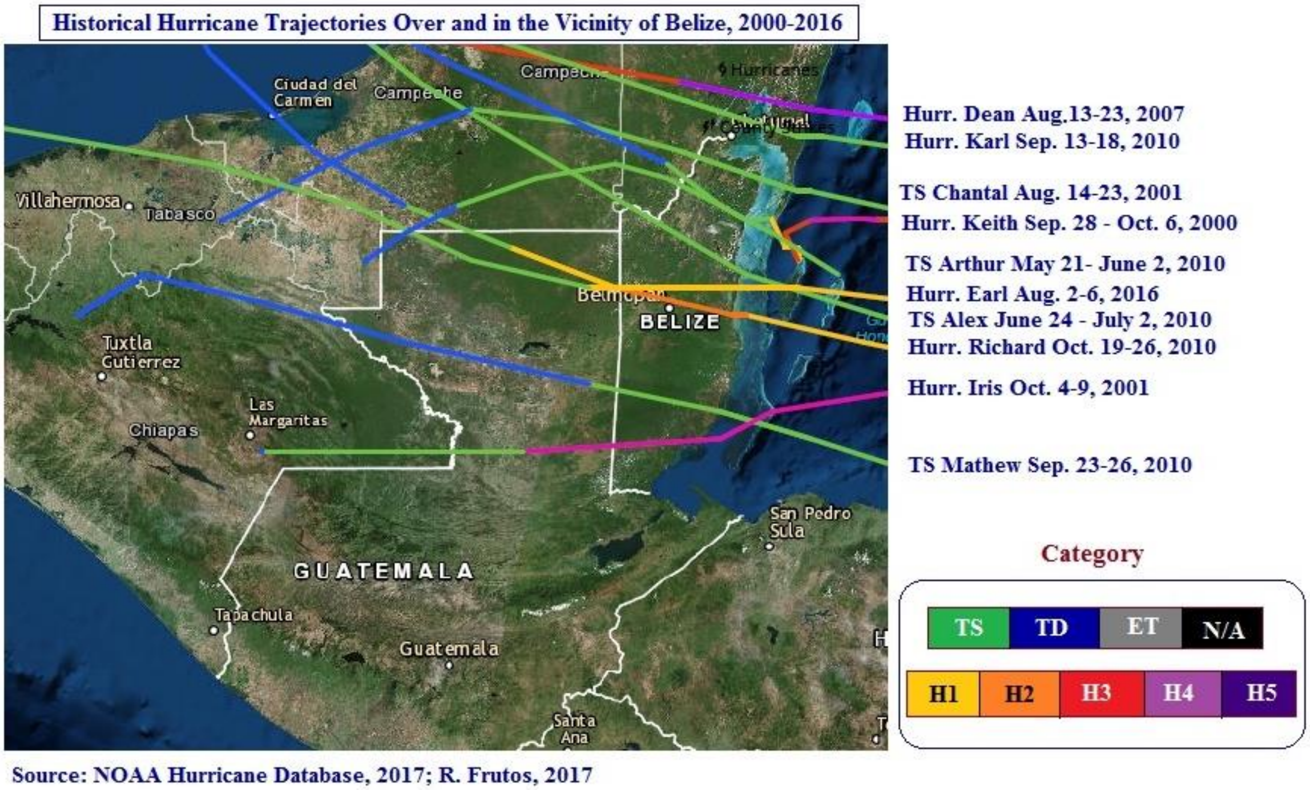


Figure 4.15: Tracks of land falling tropical cyclones over Belize (2000-2016). (Source: R. Frutos, 2017).

Table 4.3 below shows that the frequency of tropical storms and categories of hurricanes have varied over the past 118 years. Three Category 3 hurricanes, 2 Category 4 hurricanes, 2 Category 5 hurricanes affected Belize during the period (1889-2008). Since June, 2000, five tropical cyclones have affected Belize. Notably one of the category 3 (Keith), one of the category 4 (Iris) and one of the category 5 (Dean) hurricanes that have affected the country were in this decade. In this period Belize has had the following:

A. Total Tropical Storms: 53,
B. Total Years with Storms: 40,
C. Total Years with Multiple Storms: 11,
D. Total Years with Multiple Hurricanes: 3.

Table 4.3: Frequency of land-falling Tropical Cyclones in Belize (GOB, 2007).

Intensity	Events	Greater Interval Analysis
Tropical Storm	32	1 in 4.42 years
Category 1	7	1 in 12 years
Category 2	6	1 in 15.5 years
Category 3	3	1 in 34.5 years
Category 4	2	1 in 40 years
Category 5	2	1 in 52 years

Table 4.4 below is a summary of the cost in US dollars of damaged resulting from the impacts of a numbers of tropical cyclones that affected the country over the past decade. Based on the hurricane tracking maps (Figure 4.14 and Figure 4.15) and frequency analysis, the proposed rehabilitation of the PGH from Vista Del Mar junction to 1.5 miles after Biscayne Village is prone to a land-falling tropical cyclones or hurricane strikes at least once every 4 years. The historical data shows that tropical storms and hurricanes have made landfall near the proposed project site, most notable and recent were: Category I Hurricane Richard which crossed the coast just south of Belize City on October 24, 2010, and Category I Hurricane Earl that made landfall around Belize City on August 4, 2016. Therefore, due to its location in the coastal, flood-prone zone of the Belize District, the proposed infrastructural work on the PGH is exposed to the hazards associated with future land-falling hurricanes, and this must be taken into consideration in the road rehabilitation designs to increase resilience and prevent loss of life and property.

Table 4.4: Summary of estimated cost in US $ for eight recent tropical cyclones affecting Belize (Source: R. Frutos, 2017).

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

4.4.4 Storm Surge

Hazards associated with land falling hurricanes along the coast of Belize include torrential rainfall, tornadoes, storm surge, and coastal flooding. The TAOS storm surge model (OAS, 1995) projected a 1.8 meters surge in the Project site for a Category I hurricane, 5.2 meters for a category II hurricane, 7.2 meters for a Category IV hurricane and about 7.6 meters for a Category V hurricane making landfall just south of the Project site. Figure 1.8 below is a graphics of the storm surge result for a Category V hurricane crossing the central Belize District. The coastal zone east of the PGH project sector would be inundated by a storm surge in excess of 18 feet of water in a Category V hurricane, bearing in mind that such an extreme event has a return period of 50 to 100 years. The map in Figure 1.9 shows the extent of the coastal flooding associated with a storm surge produced by a land-falling Cat V hurricane near the project zone.

This adjusted flood hazard map shows flood hazards from coastal surge generated by hurricane categories 1 to 5. It does not show results for a particular event but is a combined map showing hazard for coastal area near the road rehabilitation zone with a defined probability. As can be observed, the Ladyville- Vista del Mar section of the road will be totally submerged, as well as the section of the road near Haulover Bridge onwards to Belama Phase IV and III. The source of this map is the modified 30 m SRTM from 90 m maps sourced from the Caribbean Handbook on Disaster Information Management (World Bank Group, 2016).

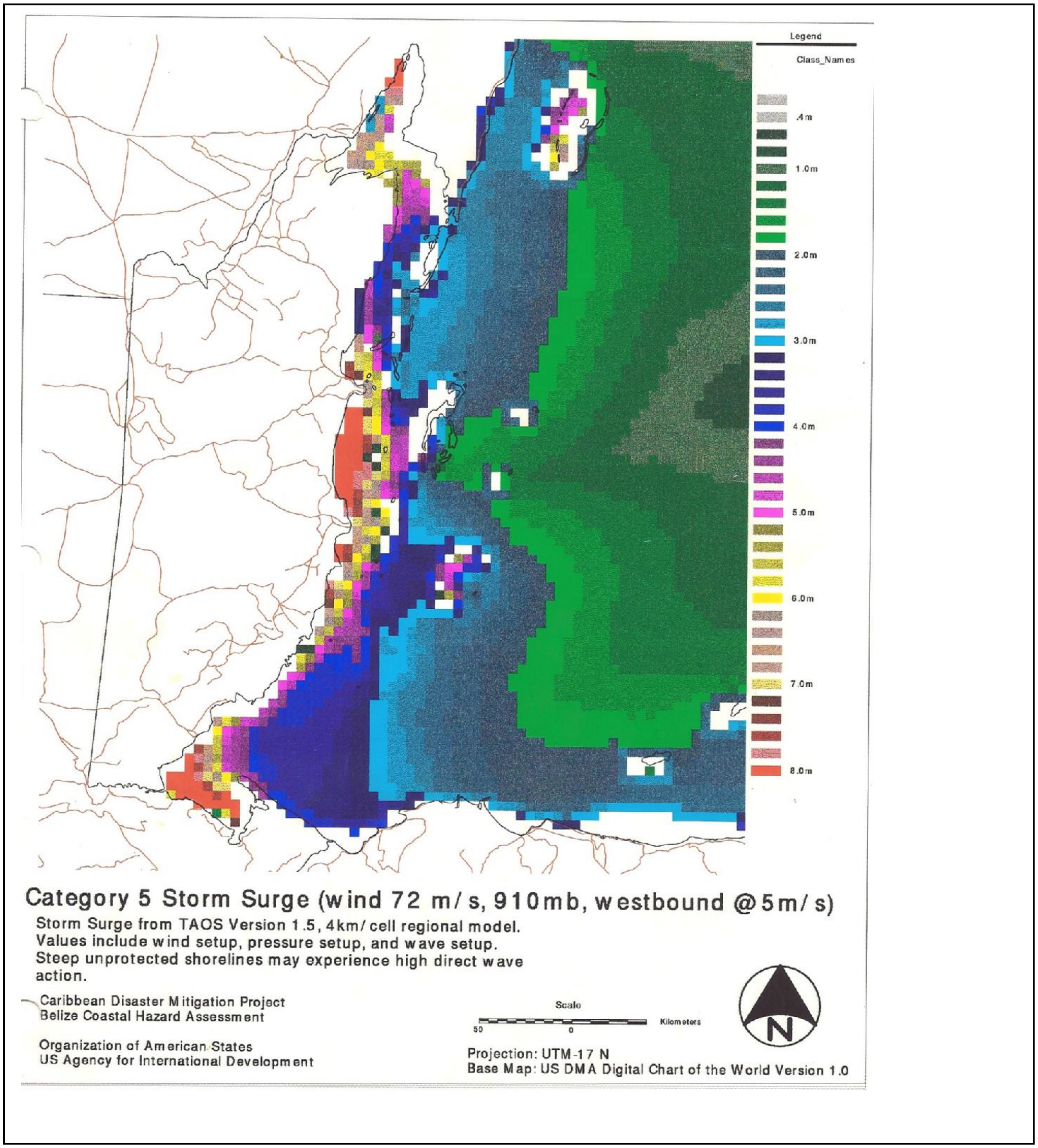


Figure 4.16: TAOS Storm Surge Model Projection for a Westward bound Cat V Hurricane moving at 11.2 miles per hour.

Hence, it would be prudent to design the link canal in the PGH area to the Vista del Mar canal for high capacity flushing, and improve the general drainage in the Airport access road and Ladyville area to reduce flooding on the highway. Another mitigation measure is to set up financial mechanisms for infrastructure and businesses in this section of Philip Goldson Highway, as a means of risk transfer for extreme hydro-meteorological events. A third mitigation measure in relation to the proposed rehabilitation of the PGH is an effective Hurricane Plan for the business sector and communities as part of the Government's Flood Mitigation Project.

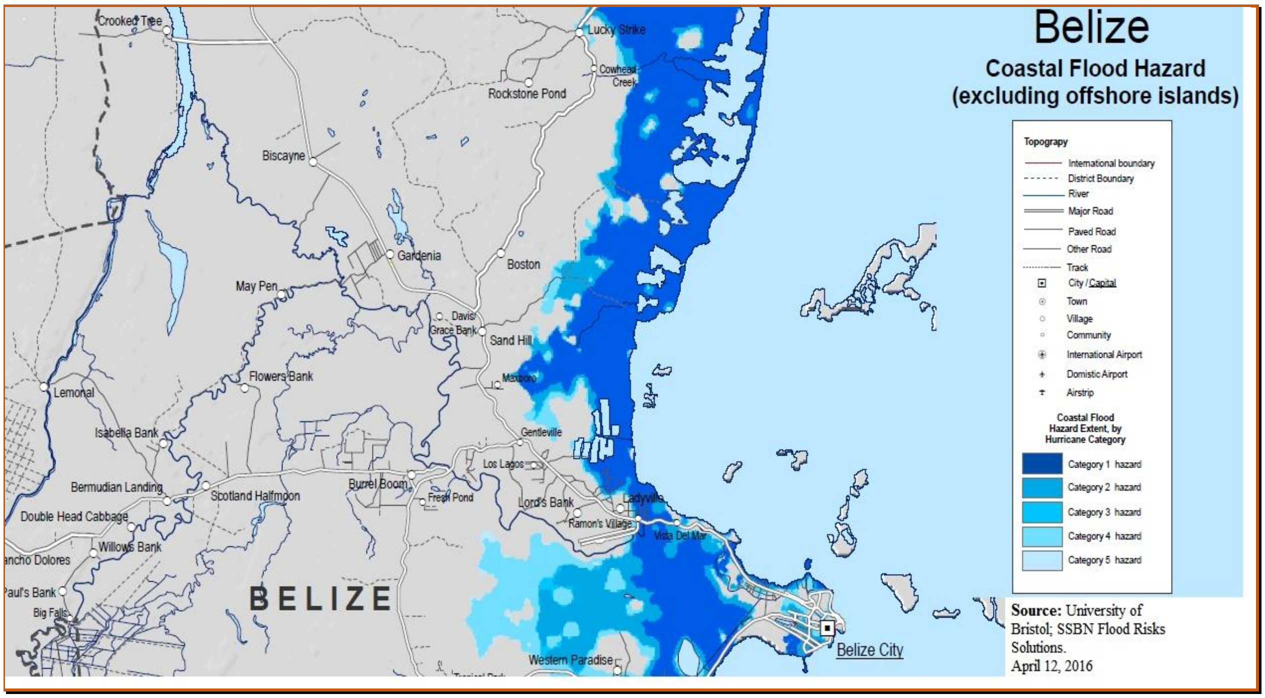


Figure 4.17: Coastal Flood Risk Map for Lower Belize River Watershed. Source World Bank Group, 2016.

4.5 Climate Change

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

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

Haites et al. (2002) estimated the economic impacts of climate change for CARICOM countries across a range of economic sectors including tourism. The authors cite a range of potential effects of climate change on tourism, including the loss of beaches due to erosion, degradation of ecosystems (e.g., coral reefs), inundation, and damages to infrastructure. The economic impact is calculated as the difference between a "low" and "high" climate scenario. In the low scenario, the temperature increases are 1.5 degrees C in 2050 and 2 degrees C in 2080, and the projected sea level rise is 0.08 m in 2050 and 0.13 m in 2080. In the high scenario, the temperature increase is 2.0 degrees C and 3.3 degrees C in 2080, and the projected sea level rise is 0.44 m in 2050 and 0.7 m in 2080. Precipitation is projected to decrease in the low scenario, particularly in the rainy season; the high scenario projects an overall increase in precipitation.

The impacts of Climate Change are already being experienced across the productive sectors of Belize, affecting the livelihood of much of the population (GOB-NCCO, 2015). As a small, insignificant contributor to global greenhouse gas emissions, Belize has limited capacity to contribute to mitigation of global climate change. However, the country is committed to play its part in support of the UNFCCC target to limit the increase of global average temperature to 1.5 °C compared to pre-industrial levels. In this respect, Belize's Nationally Determine Contribution (NDC) is guided by its commitment to strategically transition to low carbon development, while strengthening its resilience to the effects of Climate Change.

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

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

In summary the effects of climate change will be in three form of:

i) Increased surface ambient and sea surface temperatures,

ii) Sea level rise,

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

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

4.6 Hydrology

4.6.1 The Greater Belize River Basin

Belize's hydrological profile comprises of 16 major river watersheds which originate in the Maya mountains in the interior, and discharge into the Caribbean Sea. Figure 4.18 shows the location of these watersheds superimposed on a digital elevation map, and includes the transboundary sections of five (5) watersheds Belize shares with neighbouring Guatemala and southern Mexico.

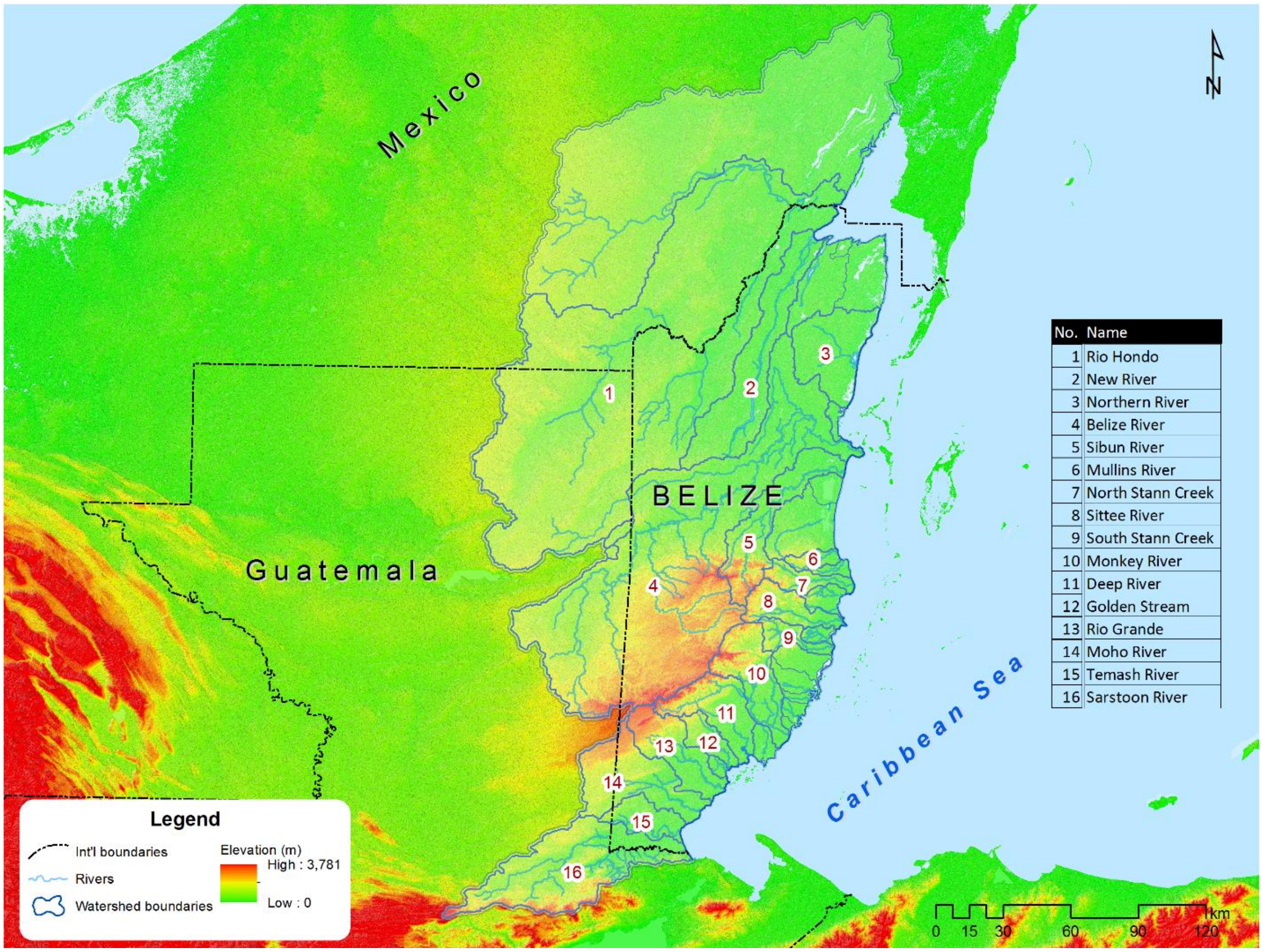


Figure 4.18: Belize's 16 major watersheds and transboundary sections in Mexico and Guatemala. (**Source: Cherrington, el al., 2014**).

The Mopan River watershed or the Western Branch of the Mopan-Macal-Belize River Basin (MMBRB) (Watershed No. 4 in Figure 4.18) has its origin in the southern Peten highlands of Guatemala, near the city of Dolores, and flows northward through rolling farmland on karstic geology, before merging with the flashy, high-energy Chiquibul River at Los Encuentros, near the border with Belize. The Chiquibul River has it origin in the south-western slopes of the Maya Mountain in Belizean territory within the southern Chiquibul Forest Reserve. The Mopan rises seasonally and contributes to floods downstream, but has a slow response to rainstorms. The Macal in contrast, comes directly from the mountains, and often rises so suddenly that is causes backwaters where it joins the Mopan. The accumulated waters of the two tributaries then become one flood wave which heads downstream through the Belize River.

The Macal River originates near Baldy Sibun, 1020 m AMSL and travels within Belize receiving contribution from many tributaries before joining the Mopan. The Macal is notorious for its flashy nature whilst the Mopan is a more meandering, consistent branch. The topography and physical character of these rivers have a direct bearing on their behaviour.

The Macal River headwaters are made up of many small streams draining out of the Mountain Pine Ridge. Very little human activity is happening here, outside of selective logging. There are very few inhabited areas, except for a few resorts, Douglas D'Silva Forest Station and San Antonio Village, along the ROW of the Caracol Road. The upper reaches of the Macal River are an important water gathering ground for the country and should be managed with that in focus.

As alluded earlier, the flow of the Macal River is regulated by the Belize Electric Company Limited (BECOL) Macal River Upstream Storage Facility and the hydroelectric plant at Chalillo, and the Mollejon and the Vaca run-of-river hydroelectric plants downstream of the Chalillo dam site. At full capacity, the Chalillo reservoir impounds 120 million cubic meter (m^3)of live storage water, the Vaca, 1.25 million m^3 and the Mollejon, 1.71 million m^3 (BECOL & ISO 14001, 2013). During flood events, excess water entering the dam results in spillage and generates an attenuated flood wave downstream in the Macal and Belize Rivers.

The transboundary Mopan-Macal-Belize River Basin (MMBRB) is vitally important to the ecology, economy, food security, and public health of central eastern Peten, Guatemala and central Belize (Boles, 2009). It is the largest catchment within Belize and is home to around 140,000 Belizeans, and 100,000 Guatemalan in El Peten. The total area of the MMBRB is 10,500 km^2, (3,300 km^2 in Guatemala, and 7,200 km^2 in Belize). On the Belize side, the Greater Belize River watershed has 11 sub-catchments. Figure 4.19 is a map of the entire extension of the MMBRB. The principal rivers are: Mopan, 174.2 km in length; Chiquibul, 138.3 km; Macal, 126.5 km; and the Belize River, 447.1 km. It has 112 communities and six (6) municipalities.

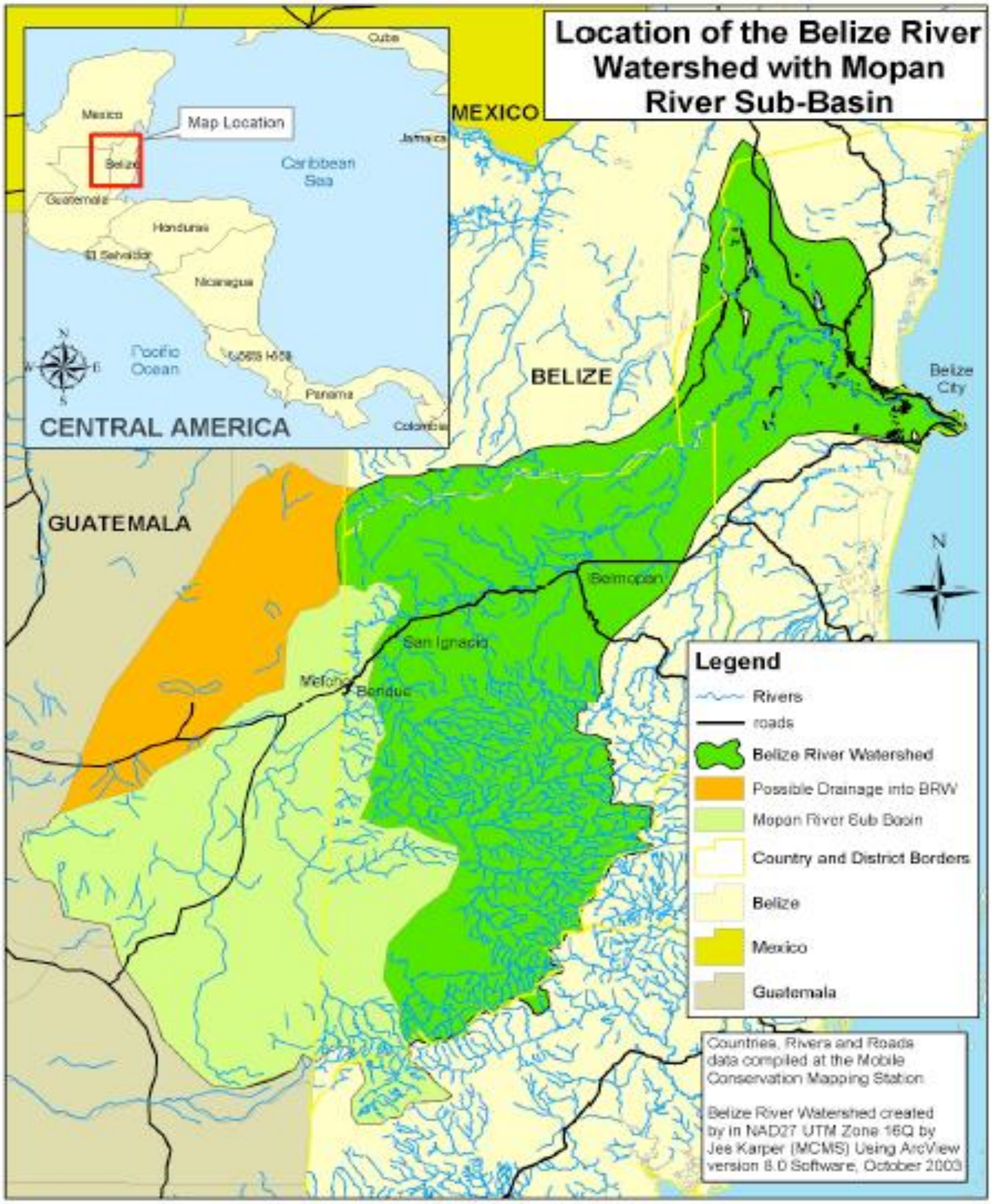


Figure 4.19: The extension of the Greater Belize River Watershed.

In El Peten, Guatemala, the MMBRB has an urbanization ratio of 85% and a population density of 21.9 persons/km^2. In Belize, the population density in the MMBRB is near 14.9 persons/km^2 and represents 31.4 % of the national territory. The Greater Belize River watershed is home to near 48 % of the population. Economic activities in the MMBRB include: agriculture, tourism, mining, fisheries, livestock, and energy. These enterprises impact surface and groundwater resources that are essential for sustainable growth and development. Figure 4.20 shows the main sub-catchments of the Greater Belize River Watershed.

WATERSHED ANALYSIS. *SUB CATCHMENTS IN BELIZE*:

- **1. Crooked Tree (Northern Lagoon)**
- **2. Laboring Creek**
- **3. Beaver Dam Creek**
- **4. Roaring Creek**
- **5. Belize River**
- **6. Iguana Creek**
- **7. Barton Creek**
- **8. Macal**
- **9. Chiquibul**
- **10. Mopan**
- **11. Other minor creeks**
- **12. Mussel Creek**

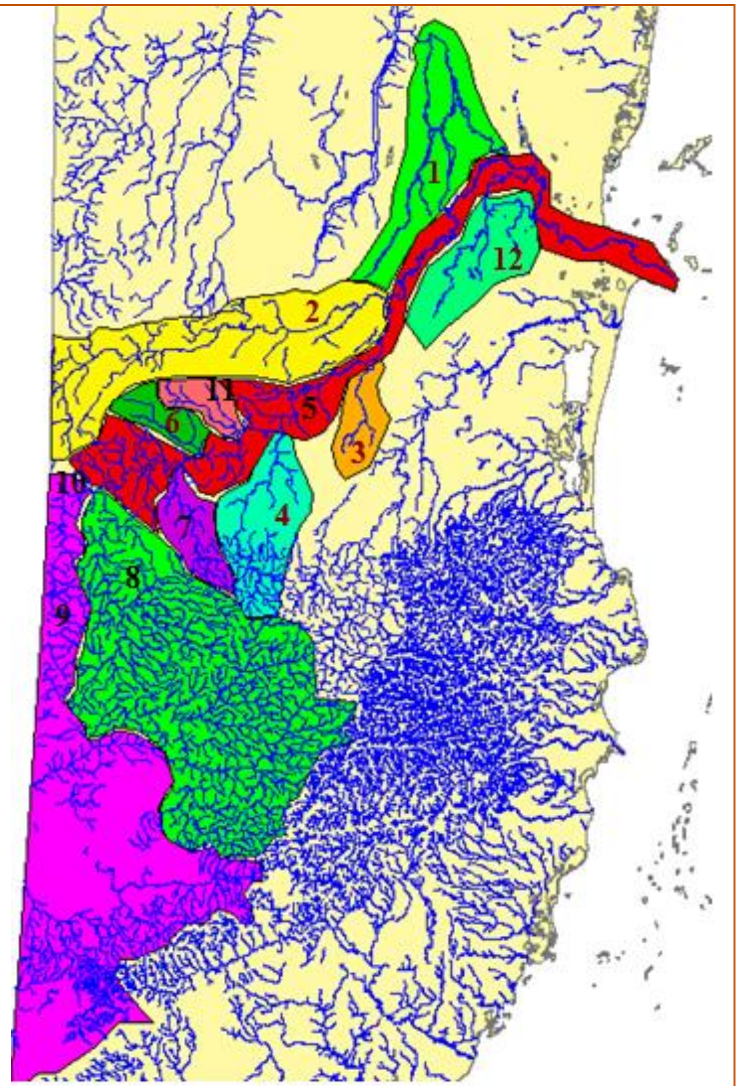


Figure 4.20: Sub-catchments of the Greater Belize River Watershed in Belize.

4.6.1.1 Belize River and the Lower Belize River Sub-catchment

The lower Belize River Basin has a low-lying floodplain that frequently floods in the rainy season. The sub-catchment of the Greater Belize River Basin (GBRB) which encompasses the section of the Philip Goldson Highway (i.e. the section from Mile 8.5 to 24.5) prioritized for rehabilitation, is at the lower reaches of the Belize River watershed. See Figure 4.21. This micro-catchment is referred to as the Belize River Mouth and Coastal Zone micro-watershed (Boles and Boles, 2009). TYPSA, in their 2010 study of the vulnerability to flood events in the GBRB, identified 10 sub-watersheds, whose physical characteristics are summarized in Table 4.5 below.

Table 4.5: Sub-catchments of the trans-boundary Greater Belize River Basins.

Belize River Sub Basins	Area km^2	Length Lc (km)	Elevation H max (m)	Elevation H min (m)
Crooked Tree/Northern Lagoon (1)	370.17	61.35	30.00	5.00
Labouring Creek (2)	2056.79	161.88	500.00	10.00
Beaver Dam Creek (3)	99.48	22.37	60.00	20.00
Roaring Creek (4)	323.16	58.76	960.00	20.00
Iguana Creek (5)	88.35	21.97	130.00	20.00
Barton Creek (6)	115.69	35.41	740.00	20.00
Macal River (7)	1468.98	126.50	900.00	60.00
Chiquibul (8)	1544.60	138.27	880.00	150.00
Mopan (9)	2044.18	174.17	700.00	60.00
Belize (10)	2388.6	447.11	700.00	0.0

(Source: TYPSA, 2010)

The Belize River sub-basin No. 10 drains an area of approximately 2,389 km^2 of the main tributary of the GBRB. This watershed has an elevation above mean sea level (MSL) ranging from 200 m at the confluence of its two main tributaries, the Mopan and Macal near Branch Mouth Village in the Cayo District, to sea level at its mouth in the vicinity of Haulover Creek just north of Belize City. The Belize River Mouth and Coastal Zone micro-watershed borders the Crooked Tree/Northern Lagoon system (Sub-basin No. 1) in the north and northwest, and extends southeast to the coast in the Ladyville/PGIA area and Belize City. It also merges with the Sibun River watershed in the south along the George Price Highway from Hattieville to the coast just north of Freetown Sibun. This portion of the micro-watershed comprises the Mussel Creek system that meanders northwards to its confluence with the Belize River opposite Grace and Davis Banks.

The area of the Belize River Mouth micro watershed is approximately 600 km^2, with elevation less than 20 m AMSL in the Sand Hill/Crooked Tree area, 10 – 5 m in the Philip Goldson

International Airport area, and 3-0 meters from the boundary with the Sibun River discharge zone to the Belize City area (see Figure 4.21). The Belize River Mouth/Coastal Zone may also encompass the Mexico/Jones Lagoon and Mexico Creek system that borders the Potts Creek watershed.

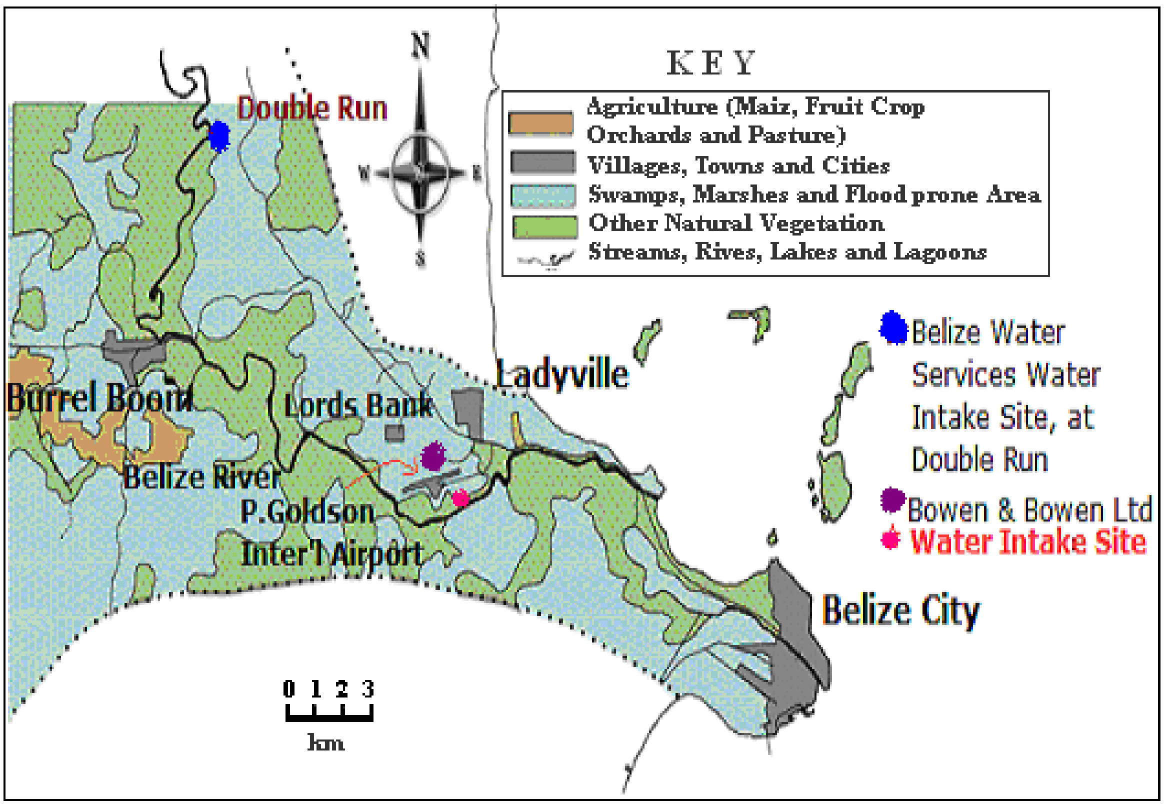


Figure 4.21: Belize River Mouth/Coastal Zone Micro-watershed and Land use.

The drainage is generally towards the main channel of the Belize River. However, during major flood events the wetlands and the Crooked Tree Lagoon System absorbs a great quantity of the excess flood water via backflows through Spanish Creek and other tributaries, resulting in widespread inundation of the floodplain in the area. As water levels in the Belize River recede, the flood waters in the wetlands slowly drains back into the Belize River. Consequently, it is vitally important to preserve the integrity of the Crooked Tree Lagoon system and other minor wetlands in the area. Unsustainable land use in the zone of influence of the PGH will only exacerbate the flooding conditions in the area.

The time of concentration of flood stage along the Belize River is dependent on where the rains fall. If the rains are concentrated in the upper watershed, a five to seven-day delay occurs before the floodwaters reach the Belize River Valley and the zone of influence of the PGH. Rains concentrated in the middle or lower reaches of the Basin, results in a shorter response time for flood conditions in the lower watershed. This was the case with the floods generated by hurricane Keith in October 2000. The bulk of the rainfall was concentrated in the NW Belize District, and the response time or flood stage was short and excessive.

The lower Belize River basin is generally an open system since the valley lies on a limestone Karst base, and floodwaters can be fed by underground flows. Furthermore, as indicated earlier, when waters begin to overflow the banks, they can traverse into other watersheds, such as the Spanish Creek watershed. From here, the waters flow into a complex of lagoons and marshes that includes the Crooked Tree Wildlife Sanctuary. In extreme storm events, such as Hurricane Keith (October 2000), waters can flow into New River Lagoon and New River, and add to the flooding in Orange Walk and Corozal districts. As river stage recedes, flood waters flow back into the Belize River through Black Creek downstream of May Pen. The very low gradient in the lower reaches of the Belize River and related basins complicates the drainage dynamics. Discharge into the sea is slowed by this minimal gradient as well as limited discharge capacity of the river mouth. Some Climate Change model predictions indicate that rainfall in the valley will increase and sea level rise will further retard the discharge of water to the sea. This could likely increase the frequency and duration of floods PGH zone of influence in the near and medium range (i.e. 20 to 50 years). Therefore, daily rainfall intensity measurement should be part of the monitoring parameters at all key Met Stations, including those in the Belize River Valley and the coastal zone.

4.6.2 The project zone

The proposed rehabilitation section (Miles 8.5 – 24.5) of the PGH traverses the lower sub-catchment of the Belize River watershed; a characteristically flood-prone region of the Belize District. Micro-catchments in the zone are: Mexico Creek, Mussel Creek, Black Creek, the Crooked Tree Lagoon System, and the lower Belize River. The vulnerability of this section of the highway was very evident during historic flood events (Tropical Depression 16, 2008; Hurricane Keith 2000; Tropical Disturbance/Cold Front system interaction, November 1979, etc.), which resulted in failing pavement, bridge infrastructural damage, traffic disruption and community impacts. Figure 4.22 is a Map showing the section of the Philip Goldson Highway from Belize City to Biscayne Village.

The PGH is a primary transit artery and evacuation route for coastal communities, including Belize City and the Cayes. Specifically, the sections of the highway most vulnerable to floods are the Vista del Mar/Ladyville area, Double Run area, and the section around Mexico Creek Bridge to Gardenia. The highway becomes submerged by one-foot or more of flood water in some sections during intense rainfall events on several occasions during the past ten years; while high-energy flood waters through Mexico Creek have strained the Mexico Creek Bridge infrastructure. Farther up at Gardenia Village, the highway runs through a floodplain, with wet lands or 'bajos' on either side. The Village is often affected by flood water from nearby Mexico Creek, making life unbearable for residence, coupled with water-borne pests and diseases.

Figure 4.22: Philip Goldson Highway from Belize City to Biscayne Village
Source: D.O.S. 649/1 North. 1:250,000. GOB, 1996

4.6.3 Field Reconnaissance and Monitoring

BET consultants conducted a preliminary *reconnaissance* of the proposed rehabilitation sections of the Philip Goldson Highway from the Ladyville/Airport Junction to Gardenia/Biscayne Villages on February 17-18, 2017.

On March 12, 2017, the team did another *reconnaissance* of the project site.

On March 16 – 18, 2017, the BET team was out conducting in situ water quality monitoring and collected water samples for laboratory analysis, and also conducted field surveys of Jones Lagoon, Black Creek, Mussel Creek, and Belize River. On March 22 and April 26, 2017 another set of water sampling activities was conducted.

Flow discharges were conducted in Mussel Creek and Black Creek on April 12, 2017 and in the Belize River and Mexico Creek on May 5, 2017.

4.6.3.1 Airport Junction and Ladyville

The poor conditions of the drainage on the road side and in the village itself were quite obvious. Culverts were blocked with sediments; vegetation and garbage (see Figure 4.23). Also evident was the clearing and filling up of the wetland, now turned into some 14.801 acres of private property on the Airport side of Ladyville, facing the Mitchell estate area. This wet land was a natural reservoir for the runoff during heavy rainstorm. A deep trench was dug on the southern, western, and eastern sides of the property with no free exit or outlet to discharge the runoff. One exit is towards the Ladyville Yellow culvert, however this culvert which crosses under the highway, is generally clogged with sediment and debris. In addition the water runoff flows away to the west of this culvert. At the western end of this trench, the drainage leads nowhere. This situation will exacerbate future flood events if not addressed properly. The proposed link canal in the area should mitigate the flooding.

Figure 4.23: Drainage Conditions in Ladyville.

4.6.3.2 Mexico Creek Bridge Crossing, Mexico Creek and Jones Lagoon

The Mexico Creek originate from the southern point of Jones Lagoon, where the water depth was observed to be between 1.5 to 2 meters earlier in mid-March. Water stage in the lagoon were above the normal low levels for the dry seasons, and some villagers suggested that the flow through Mexico Creek was reduced near the Mexico Creek itself, where material for the by-pass during bridge reconstruction after the 2008 floods, was not properly cleared, hence the elevated channel bed on the east side of the bridge, which partially blocks the stream flow to the Belize River (Figure 4.24). Very little signs of fishes and other marine life were noted in the Jones Lagoon. The Mexico Creek was observed to be cluttered with vegetation and grass, particularly in the section between the Mexico Creek Bridge and the River. The flow was noted to be sluggish and low.


Figure 4.24: (Left) Mexico Creek as it passes below Mexico Bridge. (Right) Mexico Creek as it meets the Belize River.

The initial section of Mussel Creek extending for about a kilometre, from its confluence with the Belize River, was observed to be impassable in some sections due to the thick, over hanging vegetation, fallen trees and submerged logs. The flow was low and the greatest depth was near 2.6 meter where the discharge was conducted. The width at the flow discharge site was 8.0 m. Black Creek was noted to be a larger system with a higher and steady flow at the location where the discharge was done. The width at the flow discharge site was near 19 meters, and the greatest depth on a limestone bottom was 1.8 meters. Black Creek also has many sections cluttered with overhanging vegetation, fallen trees and sunken logs, which make navigation treacherous (Figure

4.25). The proposed clearing of vegetation in all three creeks will help facilitate channel flow during flood conditions and relieve inundation of communities and road infrastructure system downstream.

Figure 4.25: (Left) Mussel Creek and (Right) Black Creek.

Water level on the Belize River was notably higher than normal for mid-April. The river water appeared turbid with suspended sediments from the runoff after the recent rains. The currents were strong around the landing at May Pen just upstream from the confluence of Black Creek, and also at Grace Bank and Davis Bank (Figure 4.26).

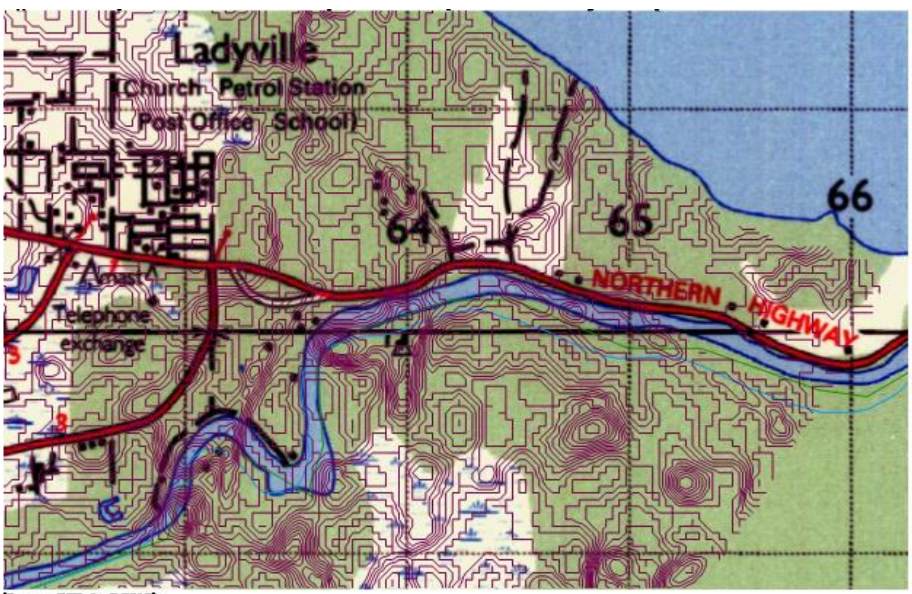
Figure 4.26: (Left) Landing at May Pen, facing down stream the Belize River. (Right), Down Stream Belize River from Grace Bank.

4.6.4 Hydrology of Study Area

The lower Belize River is the major water channel influencing the project zone, as it meanders towards Caribbean Sea from Banana Bank to its main discharge zone near Haulover Bridge, and the diversion of the Haulover Creek that passes through central Belize City.

From Ladyville to Gardenia Village, the PGH traverses the low-lying coastal plain and savannah in the first instance, then the riparian forest bordering wetlands and flood plains of the Mussel Creek and Black Creek micro-catchments to the west the highway, and the Mexico Lagoon, Jones Lagoon and Mexico Creek system on the east side of the highway.

The PGH is an artificial N-S dam (running at an average of 4-5 feet above the natural level of the floodplain/wetland) which divides the wetland into an eastern and western section, and disrupts the interconnectivity of this wetland with the Crooked Tree Lagoon system. During four extreme rainfall events, namely: the November 1979 disturbance, Hurricane Keith of October-November 2000, TD 16 of November 2008 and Hurricane Richard of 2010, sections of the PGH from Belize City to Gardenia/Biscayne were inundated for a couple days to weeks. The highway experienced pavement failure, and infrastructures were undermined (e.g. various culverts and the Mexico Creek crossing). Figure 4.27a is a DEM/1-meter SRTM (at vegetation canopy level) contour Map 1 of the proposed, PGH Rehabilitation Section



[Source: BET, April 2017]

Figure 4.27a: Map 1 DEM – 1 meter LiDAR Map for the PGH, Vista del Mar/Ladyville/Airport Junction. Source: BET, April 2017.

4.6.4.1 Flood Prone Sections of the PGH from Mile 8.5 to Mile 24.5

Vista del Mar/Airport Junction/Ladyville section of the PGH rehabilitation project is a flood high risk zone. The drainage is in effective, and the urban development in the area increased the vulnerability. The proposed link canal from PGH to Vista del Mar canal should help alleviate the ponding in the area during intense rainfall events and so help reduce the duration and extent of flooding in Ladyville and the highway.

The second section prone to flood is the Double Run Water Treatment Plant access road. Hurricane Keith (October 2000) generated high intensity rainfall of the order of 1.8 inches per hour for some 12 hours, centred in the Belize District. The result was significant runoff into the middle and lower Belize River and tributaries, and extensive flooding in the lower sub-catchments in the project zone. The high waters inundated the Double Run Plant and access road to its junction with the PGH.

The third section prone to flood in the zone from Mexico Creek Bridge through to Gardenia, where the PGH traverses the wetlands interconnected with the Mexico/Jones Lagoon system and Mexico Creek. During the 2008 TD 16 flood event, this section of the highway was submerged with a foot-and-a-half of water in some spots, with deeper waters off the elevated shoulders, and extensive degradation of the pavement and shoulders.

Figure 4.27b: Flood prone areas along the PGH from Mile 8.5 – 24.5. Source: MOW, 2015.

Figures 4.27b is a map showing the flood prone areas along the ROW of the Philip Goldson Highway.

4.6.5 Historic Stream Stage and Flow

Historic water levels for Crooked Tree Lagoon and Double Run are summarized in Table 4.6 and Table 4.7. The mean monthly river flow (m^3/s) were also computed from historic water level readings for Belize River at Double Run. Graphs of water level (stage) and flow are contained in Annex VI

Table 4.6: Historic Water Level (m) for Crooked Tree Lagoon.

Lagoon Stage	Period :	1981-2009										
Crooked Tree	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Stage	1.44	1.24	1.19	0.72	0.864	0.844	1.09	1.09	1.33	1.69	1.69	1.69
Minimum Stage	0.16	0.21	0.44	0.45	0.11	0.28	0.25	0.19	0	0.24	0.47	0.19
Year	1996	1994	2004	2004	2003	1995	2004	2004	1998	1996	1994	2004
Maximum Stage	2.51	2.22	2.25	0.95	1.28	3.15	3.2	2.77	2.66	3.27	2.75	2.84
Year	1999	1992	2003	2004	2004	2002	2002	2002	2001	2001	2003	1991

(Source: National Hydrology Department, MNR)

Table 4.7: Belize River Historic Stage and Flow at Double Run.

Double Run River Level Manually Read [m]													
Period	**1981-2009**												
Double Run	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
MEAN	1.53	0.99	0.68	0.57	0.55	1	1.56	1.56	1.83	2.64	2.49	1.92	1.42
MAX.	4.64	3.9	1.4	1.17	3.53	4.47	4.7	4.57	4.36	6.5	6.31	5.78	6.5
YEAR	1992	2006	1990	1990	1986	1986	2006	1993	1981	2000	2008	1990	2000
MIN.	0.31	0.3	0.23	0.21	0.25	0.24	0.35	0.38	0.44	0.52	0.82	0.42	0.21
YEAR	1995	1995	1995	2000	1995	1995	1998	2004	2004	1998	2002	2004	2000
Double Run Streamflow calculated from manually read water levels [m3/s]													
Mean	116	68	38.6	27.6	25.8	66.9	118	120	144	214	201	151	105
MAX.	373	310	108	86.5	286	360	382	367	351	581	557	459	581
YEAR	1992	2006	1990	1990	1986	1986	2006	1993	1981	2000	2008	1990	2000
MIN.	5.48	4.69	1.59	0.059	0.824	0.059	8.64	11	15.9	22.6	49.5	14.3	0.059
YEAR	1995	1995	1995	1985	1995	1995	1998	2004	2004	1998	2002	2004	1985

(Source: National Hydrology Department, MNR, Belize)

At Crooked Tree, the record maximum stage was 3.27 m in October of 2001. At the Double Run, the maximum or extreme stage was 6.5 m in October 2000, during the Hurricane Keith flood event. Meanwhile, the maximum or extreme estimated flow on the Belize River was 581 m^3/s, corresponding to the Keith flood event in October 2000. During the Hurricane Keith event, flood waters swamped the Belize Water Service Limited water intake plant and Double Run, and flood waters covered the access road to the Philip Goldson Highway. The estimated, historic minimum on the Belize River was 0.06 m^3/s in April, 1985 and in June, 1995. Both record low stages corresponded with drought years, with extended dry seasons.

4.6.5.1 Stream Flow Discharge

The BET team, the Golder team (Feasibility Study Consultants) and the Hydrology Unit conducted flow discharge in the Mussel Creek, Black Creek, Mexico Creek and the Belize River proper. Figure 4.28a is map of the lower Belize River watershed showing the location of the water discharge sites. The results of the discharge measurement are contained in Table 4.8.

Table 4.8: Stream flow Measurements in the lower Belize River Sub-catchments, Apr/May, 2017.

Location	*Watercourse*	*Eastings*	*Northings*	*Flow*	*Team/Date*	*Max. Depth*	*Width*	*Instrument*
				[m3/s]		*[m]*	*[m]*	
Mussel Creek	Mussel Creek	351185.28	1950958.37	**0.41**	BET; Apr. 12, 2017	2.6	8	Electro Magnetic
Black Creek	Black Creek	344540.35	1955192.45	**2.72**	BET; Apr. 12, 2017	1.8	19	Electro Magnetic
Mexico Creek	Mexico Creek	351860.66	1952349.89	**0.15**	BET; May 5, 2017	0.4	-	Electro Magnetic
Double Run	Belize River	353415.35	1948472.15	**63.58**	Golder; Feb. 3, 2017	-	-	ADCP
Boom Bridge	Belize River	352844.91	1942986.40	**6.98**	HydroMet; May 5, 2017	9.0	54.2	Valeport 106

The flow discharge for the Belize River in the vicinity of Double Run in February, 2017 was 63.6 m^3/s. Within two months in the dry season (May 5, 2017), the flow as down to near 7 m^3/s. Both from the historical records and the filed observation in 2017, one can see the high variability in the river flow in the lower Belize River in the dry season, as surface runoff becomes a minimum and the base flow is groundwater replenishment.

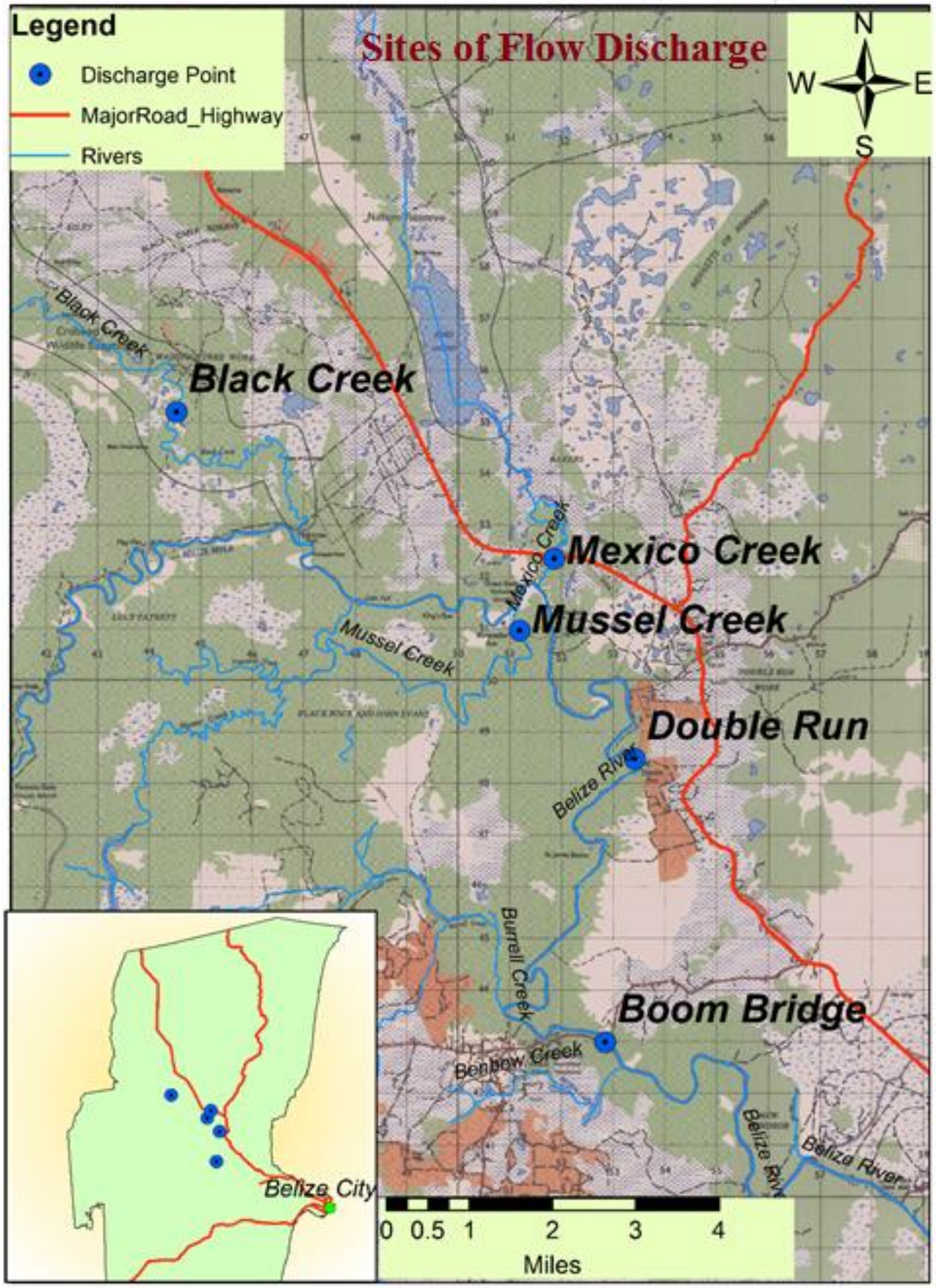


Figure 4.28a: Stream Flow Measurement Sites in the lower Belize River.

4.6.5.2 Measurement for Belize River at Double Run and Burrell Boom Bridge

The Golder team conducted the flow discharge for the Belize River at about 130 m upstream from the Belize Water Service Limited water intake and treatment plant at Double Run. The equipment used was an Acoustic Doppler Current Profiler (ADCP). The BET team used a HACH FH 950 Flowmeter to conduct the stream discharge in Mussel Creek and Black Creek. A brief overview of the HACH FH 950 flowmeter and stream flow measurement procedure is contained in the Annex VII.

The Hydrology Unit was also requested to conduct a separate flow discharge measurement for the Belize River. This was done using in early May, 2017 with the use of a Valeport flowmeter. The measured streamflow of 38.4 m^3/s is comparable with the historic mean flow in the Belize River for the dry season flow (i.e. MAM avg. flow 30.7 m^3/s). Figure 4.28b is a cross-section profile for the Belize River at the Burrell Boom Bridge. The greatest depth in Belize River at the Burrell Boom Bridge is about 9 m or (29.5 ft.).

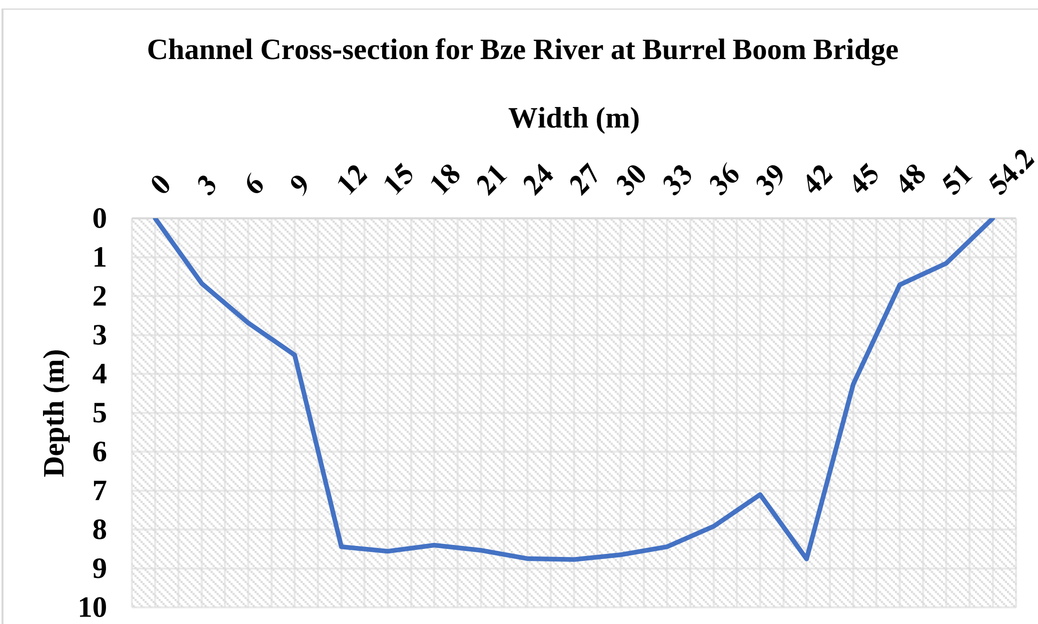


Figure 4.28b: Belize River Cross-section at Burrell Boom Bridge.

4.6.5.3: Historic Maximum Stage and Flow for the Belize River at Double Run

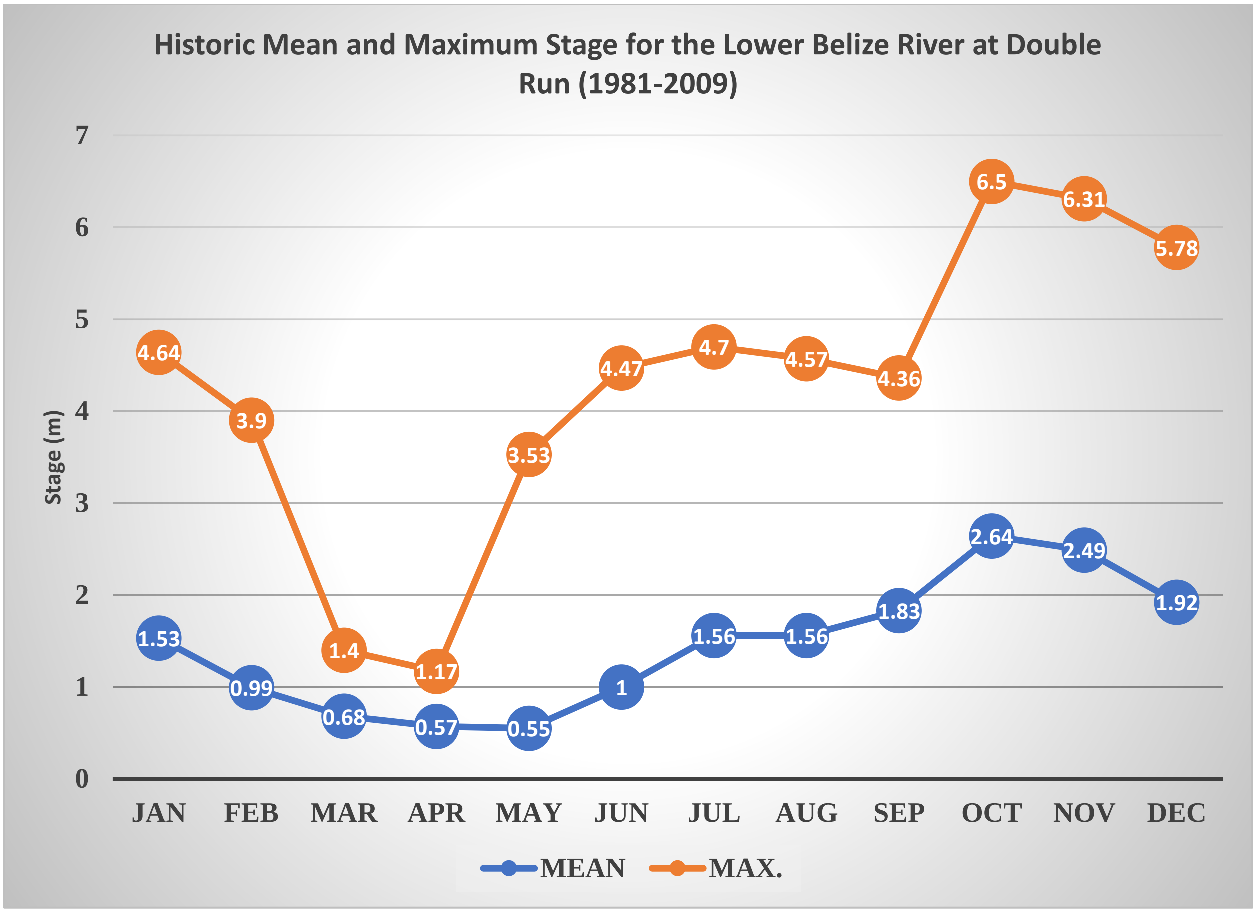


Figure 4.28c: Historic Mean and Maximum River Stage for the Belize River at Double Run.

Figure 4.28c shows a plot of the historic mean and maximum river level or stage in meter for the lower Belize River at Double Run. The extreme high stage of near 6.5 meters was generated by the runoff and flood associated with the five-day period of intense rainfall produced by Hurricanes Keith in October, 2000. The highest rainfall concentration for the period September 29th through October 3rd was in the Airport/Ladyville area of the Belize District, where a total of 830 mm were recorded. Rainfall rates were almost an inch per hour during the period of highest intensity on October 1st and 2nd. Localized flooding produced by ponding quick surface runoff began during Sunday, October 1st, 2000. The floods persisted for another week or two in the severely affected areas of the lower Belize River basin.

4.6.6 Depth, Frequency and Intensity Rainfall

Table 4.9 below contain rainfall rates and return periods for extreme rainfall values from the records at the PGIA area for the period 1983-1994 inclusive. The mean of the highest daily rainfall at this location is 149 mm or 5.9 inches. The corresponding 5-year, 10-year, 20, 50, and 100-year return period depths are summarized in the table. Mean highest rainfall value for 5, 10, 15, 30, and 60-minutes range from around 11 mm to 59 mm. Hence, from the analysis it can be deduce from the records, that the mean highest 1-hour rainfall for the Airport is about 91 mm or 3.57 inches. The 1-hour maximum rainfall for a return period of 10 years can be 106 mm and for 50 years, it can total 151 mm. Extreme rainfall is typical of climatic conditions along coastal Belize during the rainy season, and have generated coastal flood along the northern highway in the Ladyville area and within the Project Site in the recent past.

Table 4.9: Depth-Duration-Frequency, Philip S.W. Goldson International Airport (12 years of Rainfall Records 1983-94).

Duration	**5m**	**10m**	**15m**	**30m**	**60m**	**2hr**	**6hr**	**12hr**	**24h (daily)**
Mean (mm) of highest value	11.2	20.1	28.8	42.2	58.9	72.5	90.7	111.8	149
Std Dev. (mm)	3.1	5.2	13.1	18.4	26.8	25.5	22.3	33.1	46
Return Period									
5 years	14	25	42	61	85	98	113	145	196
10 years	17	29	52	75	106	118	130	170	231
20 years	19	33	62	88	125	136	147	195	265
50 years	22	38	74	106	151	161	168	226	310
100 years	24	42	84	119	170	179	184	250	343
Ratio (d/d24)	0.075	0.13	0.19	0.29	0.39	0.49	0.61	0.75	1
Note: Analysis based on an EVI distribution[6]; BECA International Consultants Ltd, 1994									

[6] Extreme Value Type 1

4.6.7 Return Period

The return period for several rainfall intensities were calculated from daily rainfall for the Philip W.S. Goldson International Airport (Drainage Report, Caribbean Development Bank, 2013), and summarized in Table 4.10.

Table 4.10: Rainfall return period and intensity for PSWGIA.

Return Period (yrs)	5	10	25	50	100	200
mm/day	15.1	27.4	42.9	54.4	65.8	77.2

For engineering use, the characteristics of the rainfall behaviour are usually captured in so-called Intensity-Duration-Frequency curves (IDF curves). IDF curves developed from daily rainfall values for the PSWGIA during the earlier feasibility study for the PGH can be seen in Figure 4.29 below.

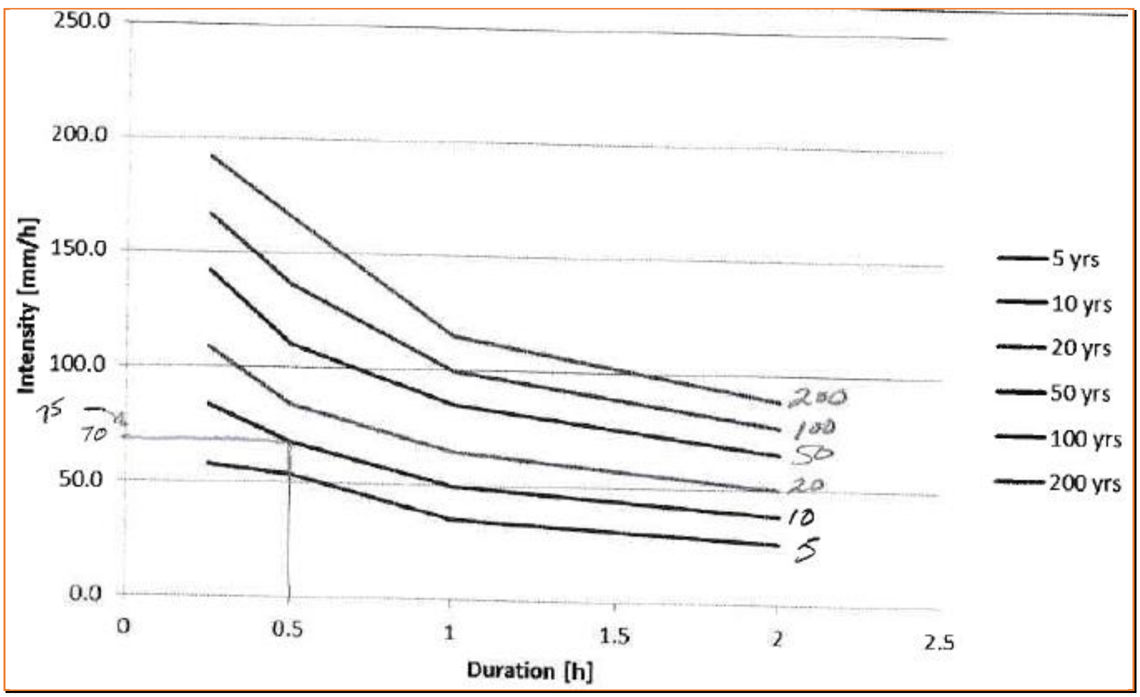


Figure 4.29: Intensity, Duration, Frequency Curves for rainfall at the Philip Goldson Airport. Source: Drainage Report, Caribbean Development Bank, 2013.

Higher intensity rainfall events resulting from climate change will lift the curve profiles to greater intensity values, but more tilted or tailing off quicker, due to higher intensity rainfall of short duration, but longer drought conditions. In general, annual rainfall are projected to decrease and will be accompanied by reduced annual surface runoff. The IPCC (2007) predicts a reduced surface runoff of about 10% to 20% for Belize. Reduced annual surface runoff in the medium and long term should be beneficial for road infrastructure, but designs should consider the effects of extreme hydro-meteorological hazards associated with more intense tropical cyclones[7].

4.7 Groundwater Provinces

4.7.1 Introduction

Groundwater is product of the rainfall regime and the geology of the landscape. Belize's geology is predominantly limestone, with the notable exception of the Maya Mountains that is composed of igneous, metamorphic, and sedimentary rocks that are from 125-320 million years old. During the Cretaceous period, the Maya Mountains stood above sea level creating the Mountain Pine Ridge plateau. The hilly regions surrounding the Maya Mountains consist predominantly of limestone formed from Cretaceous and Tertiary rocks, 1.6-65 million years old (King *et al*., 1992). These areas are characterized by a karst topography that is typified by numerous sinkholes, caverns, and underground streams. The Quaternary (Pleistocene) rocks and modern sediments along the coast, and under water, are the youngest cycle of deposition in Belize, and are represented largely by shallow-water and limy sediments. Several major faults are evident in these highlands, but much of Belize lies outside the tectonically active zone that underlies most of Central America.

4.7.2 Groundwater Resources in Belize

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

Belize is divided into seven groundwater provinces namely the Campur province, the Coastal Shelf province, the Coastal Plain and Shelf province, the Vaca Plateau province, Savannah

[7] A ***tropical cyclone*** is the generic term for a non-frontal synoptic scale low-pressure system over tropical or sub-tropical waters with organized convection (i.e. thunderstorm activity) and definite cyclonic surface wind circulation (Holland 1993).

province, the Maya Mountain province, and the Toledo province (King et al., 1992, Bukalew et al., 1998, DOE/USAID 1996). Figure 4.30 is a map showing the geographic extent of the groundwater provinces of Belize as described by King, et al. (1992). The Philip Goldson Highway rehabilitation project zone from the Vista del Mar/Ladyville area to Gardenia/Biscayne traverses a section of the Coastal Plain and Shelf, groundwater province.

4.7.3 The Coastal Plain and Shelf Province

The Coastal Plain and Shelf Province includes Corozal and Orange Walk districts and north eastern Belize district. Aquifers in this Province are composed of weathered and fractured Miocene-Pleistocene limestone and marls overlain with clay and marl alluvial deposits. Aquifers are generally confined or semi-confined inland and or perched near the coast. Aquifers are recharged from surface runoff (Figure 4.30).

Wells penetrating the unconfined aquifers range from depths of 14 to 50 meters with static levels ranging between 10 and 28 meters below the surface. Static water levels range from 10 to 26 meters below the surface. Deeper confined limestone aquifers were identified as deep as 585 meters below the surface.

Yields from the perched and unconfined aquifers average 75 L/min. The deeper and confined aquifers yield on average 331 L/min while maximum yields are near 4550 L/min. water quality is characterized by an average hardness is 372 mg/L and average sulphate content of 69 mg/L.

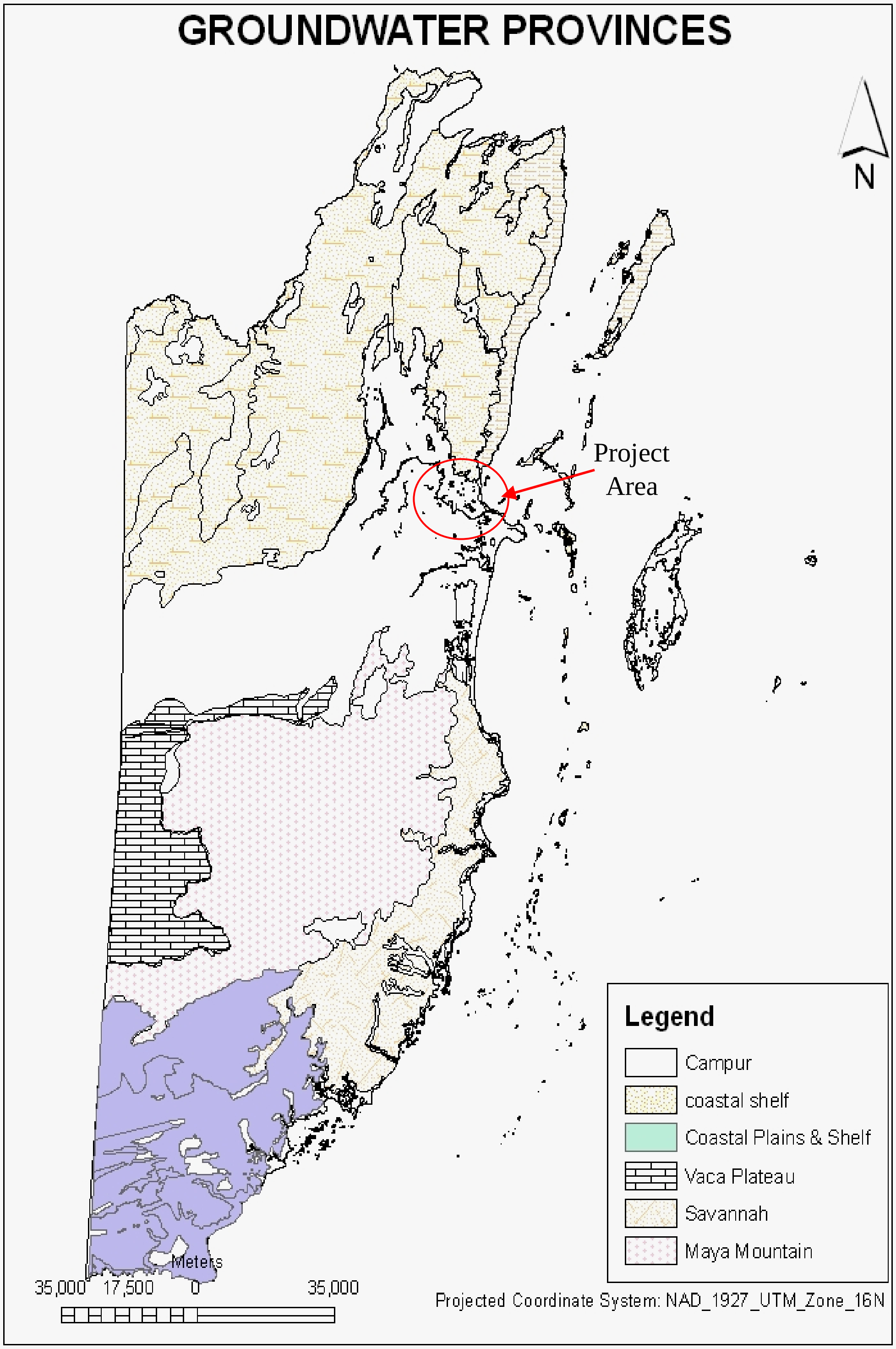


Figure 4.30: Groundwater Provinces of Belize. Source: US Army Corps of Engineers 1998.

4.8 Disaster Risk Management

4.8.1 Background

The country of Belize is prone to various hydro-meteorological hazards, which include tropical cyclones, storms surges, floods, and drought. The country's high vulnerability to natural hazards and disasters is worsen because a large majority of its population and economic activity such as agriculture, tourism, and commerce is concentrated along the exposed coastal zone and flood prone areas of the Greater Belize River Basin that drains a central zone of the country. Hurricanes, tropical storms, storm surge, and floods impacted over 300,000 persons during the period from 1970 to 2010, resulting in about 69 deaths, and in excess of US $600 million in economic damage[i], mainly in agriculture and infrastructure (NEMO, 2010).

Hazards, Risks and Vulnerability

Hazards

Hazards are potentially damaging phenomena, whether natural or man-induced.

Risks

Risk is the potential damage that could arise as a result of the occurrence of a hazard with a given degree of uncertainty. Risk is the probability of occurrence of a hazard.

A *hazard* is a source of danger, while *risk* involves the likelihood of a hazard developing into some adverse occurrence that may cause loss, injury, or some other form of damage. *Risk* may also be defined as:

Risk = Hazard x Probability of occurrence

It should be noted that the consequences of *risk* may be contained or mitigated if safeguards are put in place. However, hazards cannot be reduced to zero unless the hazard itself is removed.

Vulnerability

Vulnerability is the proportion (expressed as ***%*** *or as an* ***index*** *from 0 to 1) of what could be damaged (e.g. human life, property, etc.) in a given place because of the occurrence of a given natural phenomenon or hazard.*

Risk Management

Risk Management is the process of implementation of actions required to quantify, mitigate, and control risks. Risk Management is closely related to the concept of *safeguards* according to the NEMO (2010) Report.

Disaster Risk Management

In Disaster Risk Management (DRM) several criteria can be used to determine levels of vulnerability. These may include but are not restricted to: population density and annual growth rates, Human Development Indicators set against long-term urban growth rates, and real adjusted GDP per inhabitant set against illiteracy percentages, or set against child mortality rates. From these indicators, population density and growth rates provide an initial baseline assessment of a country's vulnerability, on the basis that countries with higher population densities are more vulnerable. Another major vulnerability criterion is poverty, which is useful in characterizing the sectors of a society that are most vulnerable to disasters. Housing, settlements, and infrastructure in disaster-prone area increase a country's vulnerability. The ex ante focus in disaster risk management is to reduce the country's vulnerability to natural hazards (IDB, 2010).

Table 4.11 is a multi-hazard assessment for some key communities in the Belize District.

Table 4.11: Summary of multi-hazard analysis for the Belize District.

Location Hazard	**Ladyville Vista del Mar**	**Burrell Boom**	**Sand Hill**	**Crooked Tree**	**Biscayne**	**Gardenia**	**Caye Caulker**	**Isabella Bank**	**Lemonal**	**Santana**	**Rockstone Pond**	**Bomba**	**Corozalito**	**May Pen**
Flooding or Inundation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Storm Surge	Yes						Yes							
Fire/Explosion	Yes		Yes	Yes	Yes									
Risk Ranking	H	M	M	H	M	H	H	M	M	H	L	L	H	H
Source of data: NEMO, 2014														

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4.8.2 Climate Change

Climate change is invigorating the hydrological cycle and increasing disaster risk in Belize. The negative impacts of climate variability and change are projected to increase in intensity during the 21st century, and infrastructures such as the PGH will become even more vulnerable to the extreme events generating localized flood along certain stretch this and the other main road systems of Belize. Consequently, the GOB with support of the Inter-American Development bank is pushing greater emphasis on ex-ante risk reduction, and incorporates Integrated Disaster Risk Management (IDRM) into the core operations of NEMO and Public Sector institutions. In light of this the rehabilitation of the PGH is a step in the right direction to reduce the risks of natural disasters on local population and ameliorate property loss and suffering. The road system itself must be redesigned with ex-ante risk reduction in mind to safe guard its integrity for medium and long term.

The PGH forms a critical section of the Pan American Highway, that serves the transportation of goods and services during normal time, and especially so during emergency situations when other sections of this regional highway artery is disrupted, such as was the case when flash floods washed sections of the highway in southern Mexico and Guatemala in October-November, 2008.

In Belize the PGH is a critical evacuation avenue during before and during a disaster. Hence, the proposed road upgrading designs should be of international standards to make PGH resilient to the impacts of future extreme events including earthquakes.

4.8.2.1 Two approaches to conduct vulnerability and adaptation assessments for Climate Change

The first generation of assessments is 'scenario based approach' that answers the question: "what are the climate change impacts?" (See Figure 4.31.) The focus is on:

- Climate scenarios
- Biophysical and socioeconomic impacts
- Prioritize and implement adaptation measures
- Mainstreamed residual or Net impacts to reduce vulnerability

The second generation of assessments is: ‘vulnerability-based approach’ that answers the question, “How to adapt?”

- Climate science highlights current and future exposure
- Social science reveals the current and future adaptive capacity
- Current exposure and current adaptive capacity gauges the current vulnerability
- Future exposure and future adaptive capacity projects the future vulnerability.

With respect to the project area connected with the proposed rehabilitation of the PGH, two fundamental elements are considered in the evaluation of vulnerability to the impacts of climate variability and change. These are: the communities along the highway within the 8 km wide zone of influence of the PGH, and the current and rehabilitated sections of the PGH itself.

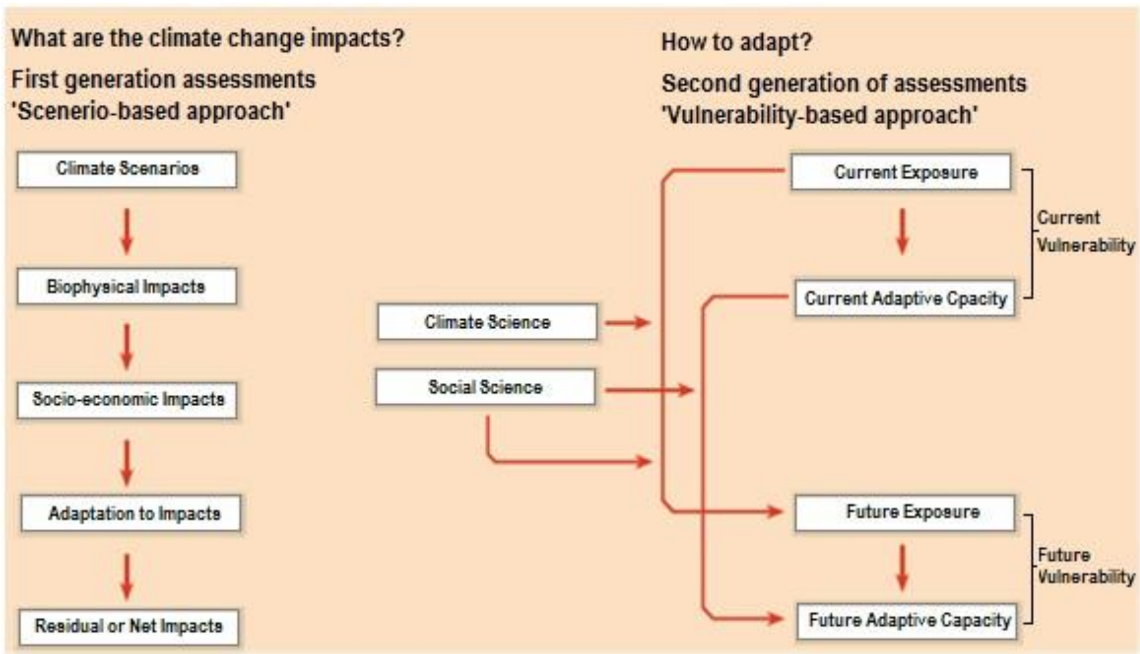


Figure 4.31: Two approaches to conduct vulnerability and adaptation assessments for Climate Change.

4.8.2.2 Climate Change projections for Belize and Risks of Occurrence

The Hadley Center in the UK, Regional Climate Model (RCM): “Providing Regional Climate for Impact Studies (PRECIS) for Belize for the years 2050 and 2080 are summarized in Table 4.12.

Table 4.12: PRECIS climate projection for Central Belize, 2014.

Element	Trend	2050	2080-2099
Mean Surface Temperature	Rising 0.8 °C past 50 years	+1.5 to +2 °C rise. *Probability: very likely*	+3.5 to +4.0 ° C rise *Probability: very likely*
Rainfall	Rising 44 mm past 50 year	Variable -30% to + 20% change from base line year 2070-2000 *Probability: likely*	Very variable: -60 % to +20% change from baseline year 2070-2000 *Probability: likely*
Seasonal Evapotranspiration	Rising past 40 years	Slight decrease in dry season deficit; decrease in wet season surplus *Probability: likely*	Significant decrease in wet season surplus projected by regional climate *Probability: likely*
Seasonal Rainfall pattern	Becoming more variable	June, July and August becoming drier *Probability very likely*	Marked variability in June, July and August rainfall – drier *Probability: very likely*
ACE (Tropical Cyclone)	15-20 year upsurge cycle, (1950- 1979; 1995-2010; …)	Warmer ambient temperature and warmer SST conducive to extended period of ACE upsurge. More intense TC likely *Probability: likely*	Energized hydrological cycle may likely result in increased intensity and frequency in North Atlantic Hurricanes…Some of the Climate models favour this scenario, others don't *Probability: likely*
Sea level rise	Increasing at the rate of 0.33 mm per year	Coastal Belize & western Caribbean: 0.15-0.30 m *Probability: likely*	Coastal Belize & western Caribbean: 0.30 – 0.60 m *Probability: likely*

Virtually likely >99% probability of occurrence; *Extremely likely*> 95%; *Very likely*> 90%; *Likely*> 66%; *more likely than not* > 50%; *Unlikely* < 33%; *Very unlikely* <10%; *Extremely unlikely* < 5%.

(Source: CCCCC, PRECIS-ECHAM5- A2 Scenario data and analysis; Frutos, 2014)

Temperature: It is *very likely* (> 90% probability) that by mid century the mean surface temperatures will be between 1.5 °C – 2.0 °C, relative to the 1970 – 2000 climatology value in Belize.

Rainfall and Change in Seasonal Pattern: Likely (> 66% probability) that rainfall will be very variable, changing from -30% to +20% of the baseline of climatology mean by mid century. The models project that the June, July, and August season will become drier. Meaning that the onset of the wet season will shift to later dates, and the dry seasons will be longer. More drought conditions!

Accumulated Cyclone Energy (ACE): More intense Tropical cyclones are *likely*. Warmer ambient and sea surface temperature and increased, ocean heat content, will favour extended periods ACE upsurge per hurricane season in the Atlantic Basin.

Sea Level Rise: It is *likely* that sea levels will rise in the western Caribbean and coastal waters of Belize by 0.25 – 0.30 m above the baseline period (1970-2000) value by mid-century. This may likely under-estimated, and the results will be increased vulnerability to higher storm surge and widespread coastal flooding in some areas.

4.8.2.3 Results of Climate Change Survey

Ten "Climate Change and Disaster Preparedness" questions were prepared, tested and incorporated into the Socioeconomic and Environmental survey instrument that was used in the survey conducted among a random selection of community households in the zone of influence of the PGH rehabilitation project

General Results

Refer to the Annex VIII for graphical results of the Survey.

CC 1A. IN YOUR COMMUNITY, HAVE YOU NOTICED CHANGES IN THE WEATHER PATTERN IN RECENT YEARS?

Biscayne: Majority, 50% answered "Yes", 30% "No", and near 20% "Don't Know - DN"

Gardenia: Near 60% reported "Yes", while about 25% answered "No"

Ladyville: The majority answered "Yes" (55%). About 38% answered "No"

Lord's Bank: The majority answered "Yes" (65% of persons surveyed).

Sandhill: About 60% answered "Yes". Near 38% responded "No". The remaining 2% did not know.

CC1B. WHAT TYPE OF CHANGE/S HAVE YOU NOTICED?

The majority (60%) of respondents indicated “Change in the weather, hotter”. Near 10% of those surveyed opted for “Longer dry” and “Less Rains”, respectively. Other “changes” cited were less than 5%.

CC1C. HAVE YOU EVER EXPERIENCED ANY MAJOR FLOODING IN YOUR COMMUNITY?

The majority of villagers responded “No”. In Ladyville, 30% answered “Yes”, while in Biscayne about 45% also responded “Yes”. They have experienced major flooding in their village.

CC1D. IF YES, CAN YOU RECALL THE LAST 2/3 TIMES (MONTH/YEAR) AND THE EVENT WHEN THE COMMUNITY WAS FLOODED?

The event that carried the highest percentage of response (near 65%) was Hurricane Earl. It is very likely that this was the case because the impacts of Hurricane Earl still rest in the minds of villagers. The other natural hazard that people indicated was “Hurricanes” in general, with a 20% response.

CC 2. HAVE YOU EVER HEARD OF THE TERM “CLIMATE CHANGE?

The majority of villagers were in affirmative to having heard about Climate Change (60% - 80%). Less than 35% answered “No”.

CC3. WHICH OF THE FOLLOWING, IF ANY, DO YOU THINK IS/ARE RELATED TO CLIMATE CHANGE (SELECT ALL THAT APPLY):

Respondents were unanimous that “All the Above” phenomenon listed were related to Climate Change. “Changing Weather Patterns” was popular with survey respondents from Ladyville, Lord’s Bank, and Sandhill. One may infer from specific choices of phenomenon related to Climate Change selected by respondents, that they are generally familiar with the effects of climate change. This is compatible with the 60% to 80% of respondents who indicated that they have heard about Climate Change.

CC 4. DISASTER RISK REDUCTION ARE ACTIONS TAKEN TO REDUCE THE EFFECTS OF NATURAL OR MAN-MADE HAZARDS. INDICATE WHICH OF THE FOLLOWING IS/ARE BEING CARRIED OUT IN YOUR COMMUNITY TO ADDRESS THE THREATS OF HAZARDS?

The survey results showed that the majority of respondents did not know what is being carried in their villages to address the threats of hazards. In addition, the choice with the second highest percentage was “None of the Above”. The thirds most popular response was, “Sensitize community members”. Thus, there seems to be complacency among the authority and villager leaders on the urgent need to be prepared for imminent natural hazards, and a general lack of communication with stakeholders.

CC5A. THERE IS A PROPOSAL TO UPGRADE THE SECTION OF THE PGH THAT PASSES THROUGH OR NEAR YOUR VILLAGE DO YOU THINK THIS WILL HELP TO REDUCE THE EFFECTS OF HURRICANE HAZARDS (FLOODS AND FLASH FLOOD, STORM SURGE, DRAINAGE, ETC.) IN YOUR VILLAGE?

The majority of respondents (some 60% in Biscayne, 65% in Ladyville, near 85% in Lord’s Bank, and 75% in Sandhill) indicated that the proposed upgrade of the Philip Goldson Highway will help reduce the effects of hurricane hazards. The exception was Gardenia, where the majority respondents (near 50%) answered “No”. About 30% of those surveyed in Gardenia answered “Yes”, and 20% did not know.

CC5B. IF NO, WHY NOT?

Responses as to why the upgrade of the PGH will not help to ameliorate the hurricane hazards were not fort-coming.

CC6. DO YOU THINK AN UPGRADED PGH THROUGH OR NEAR YOUR VILLAGE WILL HELP IN THE RESPONSE EFFORTS TO REDUCE THE IMPACTS OF HURRICANE HAZARDS (FLOODS AND FLASH FLOOD/STORM SURGE ETC.) OR A MAN-MADE HAZARD?

Results are the same as those in CC5A above.

4.8.3 Significant Rainstorm Events that Impacted Belize

Table 4.13 is a summary of the major, historical tropical disturbances and tropical storms that affect the country of Belize over the past 50 years.

Table 4.13: Significant Wind & Rainstorm Events that affected Belize since 1974.

Year	Events
1974	• Hurricane Fifi destroys laboratory structures, uproots coconut trees, and reduces the surface area of Carrie Bow Cay by about one third, to 0.4 hectare.
1978	• Hurricane Greta destroys Carrie Bow Cay field station.
1998	• Island clean up and design for new field station completed. Construction work initiated but delayed by flooding and coastal erosion from Hurricane Mitch • Hurricane Mitch threatens, powerful wave actions degraded beach fronts, but catastrophic Hurricane Mitch moves south across Bay Islands & Honduras • Serious coral bleaching and die-off on reefs off Carrie Bow and Pelican Cays observed, partly caused by hurricane Mitch
2000	• Powerful Hurricane Keith impacted San Pedro, Ambergris with a storm surge of 4 – 5 feet, and caused extensive beach erosion
2001	• Hurricanes Michelle and Iris (October) barely miss Carrie Bow Cay, causing some damage to buildings and heavy beach erosion and devastate 3 (Iris, in particular) large areas in southern Belize. Compact hurricane Iris (120 mph wind, Cat 4) made landfall around Monkey River Town on October 9. A storm surge of 8 – 15 feet was reported for Southern Placencia and Independence.
2003	• Hurricane Claudette threatens Carrie Bow (July) and necessitates temporary evacuation
2005	• Thirteen hurricanes formed this season. Three category five hurricanes (Katrina, Rita, and Wilma) caused substantial coastal erosion and damage to the Carrie Bow facilities. The record number of 25 named storms in the Caribbean broke the previous record (from 1933) of 21 named storms
2007	• Hurricane Dean strikes Northern Belize and Yucatan, Mexico (August), Felix passed over Honduras south of Belize (September); both cause major beach erosion at Carrie Bow Cay but no damage to buildings.
2008	Tropical Depression 16 generated widespread flooding across the Greater Belize River Basin. The lower Belize River sub-catchment was severely impacted by the flood wave emanating from the upper reaches of the Watershed. Flood conditions lasted for several weeks, before the water levels receded.
2010	• Cat 1 Hurricane Richard tracked over southern Turneffe Atoll and made landfall near Gales Points.
2011	• Tropical Storm Harvey forces evacuation and makes landfall in Belize, no damage was caused to the station.
2012	• Hurricane Ernesto tracked near Belize in early August, threatening to force evacuation of the island; the storm tracked north and caused no damage to the island.
2016	• Cat 1 Hurricane Earl made landfall over Southern Belize district on August 3, producing a storm surge of 2 – 3 feet and widespread beach erosion

(Source: CRRE, 2013; NMS, 2016; NOAA, 2016)

4.8.4 Dam Break - Possible Maximum Flood

The Belize Electric Company Limited (BECOL) Upper Macal River Hydroelectric Facilities at Vaca, Mollejon, and Chalillo are now fully operational and generate about 55% of Belize's energy needs. In accordance with the April 5, 2002 Environmental Compliance Plan (ECP), BECOL, in collaboration with NEMO and other stakeholders, developed and operationalized a Dam Safety *Emergency Preparedness Plan* (EPP), specifically under the Chalillo Hydroelectric Project. According to BECOL, the dam is designed to meet and exceed all standards for dam safety, however the plan is developed in the interest of public safety should an unlikely dam break emergency scenario arise.

The EPP is designed to deal with any problem experienced with the integrity of the Chalillo Dam structure. As indicated earlier, the EPP was formulated in conjunction with relevant agencies responsible for activities during natural disasters in the area of public safety. Figure 4.32 shows the Chalillo dam spilling after heavy rainfall in the area.

Figure 4.32: Chalillo Dam Spilling after period of Heavy Rainfall.

While the dam is designed not to fail, a monitoring plan for recording changes in dam structure and hydrology is in place, and compliments the response measures outlined in the EPP should an emergency related to a dam failure occurs. The dam break study and assessment done in preparation of the Chalillo EPP indicated that the *Probable Maximum Flood* (PMF) for the Macal River would generate a higher river flow than a dam break (120 million m^3), under normal weather conditions. The vision of BECOL and the disaster emergency agencies of Belize is that a well-tested EPP will increase public safety and reduce property damage in the event of a dam break emergency.

The purpose of the EPP is to:

- Provide a plan, which facilitates public safety by notifying all appropriate authorities;

- Provide information to all stakeholders to allow for an informed evaluation to be made during emergency events;
- Provide plan of action for foreseeable flood emergencies affecting safety of the Chalillo Hydroelectric Facility and affected property downstream;
- Provide for a plan of action to carry out repairs and reduce the impact of any such event where possible.

In summary the plan is intended to assist BECOL, local community authorities, the District Emergency Management Organization (DEMO), the National Emergency Management Organization (NEMO), and other agencies in responding swiftly and effectively in the event of a dam safety emergency at the Chalillo Hydroelectric Facility.

Although the probability of such an event is small throughout the projected 50 year lifespan of the Chalillo dam, the possibility of such an event still hangs over the head of all communities and interests downstream of the dam.

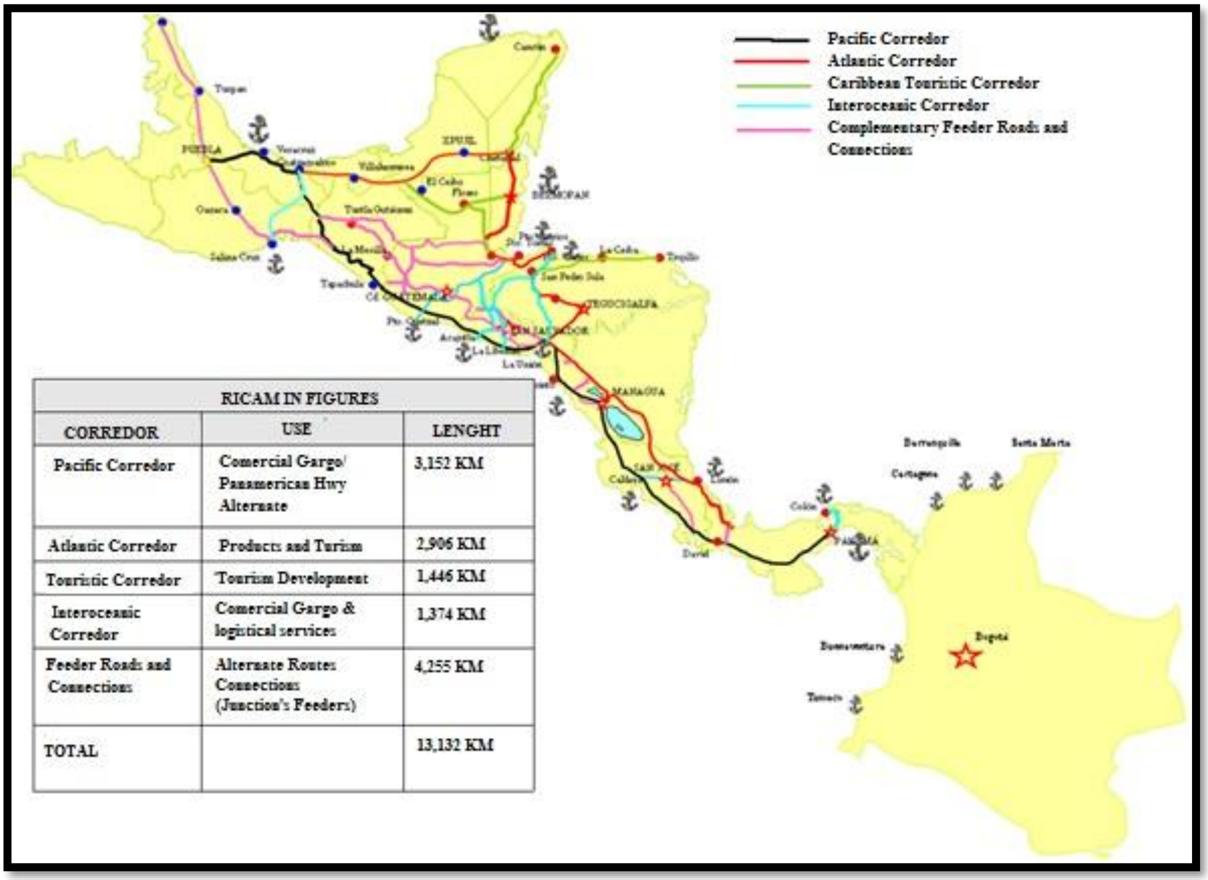
4.8.5 Hazards to the PGH and Communities in the Study Area

The lower reaches of the Belize River and tributaries have a very low gradient. The river discharge into the sea is slowed by the low gradient, as well as limited discharge capacity of the river mouth caused by sediment build-up and debris, among other factors accumulating over the years. Some model predictions indicate that with climate change, precipitation in the Belize River Basin and its upper reaches will increase, while sea level rise will further retard the discharge of water to the sea. Other factors include the rapid urbanization along sections of the highway and the conversion of natural wetland and forested areas for housing and industrial use, thereby changing the hydrology in critical areas of sub-catchment. The combined result of this is a higher probability for an increase in the frequency and duration of floods in the future that will impact the integrity of the highway and communities.

The importance of the PGH cannot be over stressed. This road artery connects Belize City, the economic centre to Orange Walk Town, the sugar capital, and Corozal Town the northern most community to the Mexican southern Border.

It is also the main access to the Philip Goldson Airport and serves as one of two main evacuation routes during a hurricane emergency. Regionally, the Philip Goldson Highway as well as the

George Price Highway form part of the Northern Route of the Inter American Highway Network. Figure 4.33 shows the regional road network which forms an integral part of the RICAM project.



RICAM IN FIGURES		
CORREDOR	USE	LENGHT
Pacific Corredor	Comercial Gargo/ Panamerican Hwy Alternate	3,152 KM
Atlantic Corredor	Products and Turism	2,906 KM
Touristic Corredor	Tourism Development	1,446 KM
Interoceanic Corredor	Comercial Gargo & logistical services	1,374 KM
Feeder Roads and Connections	Alternate Routes Connections (Junction's Feeders)	4,255 KM
TOTAL		13,132 KM

Figure 4.33: The PGH and the Regional Integration of Central America and Mexico (RICAM (translated)).

The main natural hazards that threaten the integrity of the PGH include: i) Land-falling tropical cyclones and hurricanes; ii) other extreme hydro- meteorological phenomenon such as Meso-scale convective complex, upper level cold core lows; active tropical waves, local tornadoes etc.; floods; bush fires; and heat waves.

Technological hazards that may pose a threat to the highway's integrity and the smooth flow traffic include oil and chemical spills; explosions; excessive speeding resulting in road fatalities, etc.

4.9 General Ecology of Project Area

4.9.1 Ecosystems of the Study Area

Twenty two ecosystems have been categorized and mapped within the project area, and include 3 modified ecosystems that result from the impacts of anthropogenic fires on the natural pine savannah habitats (2 shrub lands and a short-grass savannah with scattered trees or shrubs), and 3 man-made systems (Urban, Agro-productive systems and Aquaculture) Figure 4.34). In broad terms the natural terrestrial ecosystems fall within three broad categories: broad-leaved forest, Pine savannah, and wetlands:

Broad-leaved Forest Ecosystems

Tropical evergreen seasonal broad-leaved lowland forest on calcareous soils

Tropical evergreen seasonal broad-leaved lowland forest on poor or sandy soils

Tropical evergreen seasonal broad-leaved alluvial forest, occasionally inundated

Tropical evergreen seasonal broad-leaved lowland swamp forest, short tree variant

Tropical evergreen seasonal broad-leaved lowland swamp forest, tall variant

Pine Savannah Ecosystems

Short-grass savannah with dense trees or shrubs

Short-grass savannah with scattered trees and/or shrubs

Deciduous broad-leaved lowland shrubland, poorly drained

Deciduous broad-leaved lowland disturbed shrubland

Wetland Ecosystems

Eleocharis marsh

Tall-herbs lowland swamp

Marine salt marsh

Caribbean mangrove forest, mixed mangrove scrub

Caribbean mangrove forest, coastal fringe mangrove

Caribbean mangrove forest riverine mangrove

Caribbean mangrove forest, basin mangrove

Of the ecosystems present within the project scope, a number are highlighted as under-represented under the National Protected Areas System (NPAS) Table 4.14.

Table 4.14: Ecosystems with less than 10% coverage in the NPAS.

ECOSYSTEM	UNESCO CODE	% in NPAS
Tropical evergreen seasonal broad-leaved lowland swamp forest, tall variant	1A2g(1)(a)-T)	8.0%
Eleocharis Marsh	VD1a(1)	8.0%
Mixed Mangrove Scrub	1A5a(1)(c)	9.3%

(10% is the IUCN recommended lower limit for representation)

Tropical evergreen seasonal broad-leaved lowland forest on calcareous soils (UNESCO Code: 1A2a(1)(b)K)

This forest type is found primarily to the east / north-east of Sandhill, and to the west of the Village, stretching westwards from the Belize River. The soils in this area are deep, calcium rich, usually sandy, and moderately well drained. Frequently encountered species include: *Acoelorrhaphe wrightii, Attalea cohune, Bactris major, Bactris mexicana, Calathea lutea, Calophylum brasiliense, Ceiba pentandra, Chrysophyllum sp., Coccoloba belizensis, Costus sp., Cupania belizensis, Desmoncus orthacanthos, Ficus* spp., *Guarea* sp., *Hampea trilobata, Heliconia latispatha, Luhea speciosa, Lysiloma sp, Manilkara zapota, Maranta arundinaceae, Pimenta dioica, Pouteria* sp., *Pterocarpus sp., Sabal mauritiiformis, Samanea saman, Schizolobium parahybum, Simarouba glauca, Spondias mombin, Stemmadenia donnell-smithii, Swietenia macrophylla, Tabebuia rosea, Tabernaemontana arborea, Virola koschnyi, Vitex gaumeri, Vochysia hondurensis, Zanthoxylum* sp., *Zuelania guidonia.*

These forest tracts suffered significant structural damage from Hurricane Earl in August 2016, with the upper branches of most of the taller (20-25m) trees snapped off, leaving the storm-resistant royal palms as emergents above most of the remaining vegetation. This ecosystem is a favoured habitat for the endangered Yucatan black howler monkey (*Alouatta pigra)*, which seems to have largely withstood the immediate impacts of the storm (Champion, J., pers. com.; Walker, P. pers. obs.).

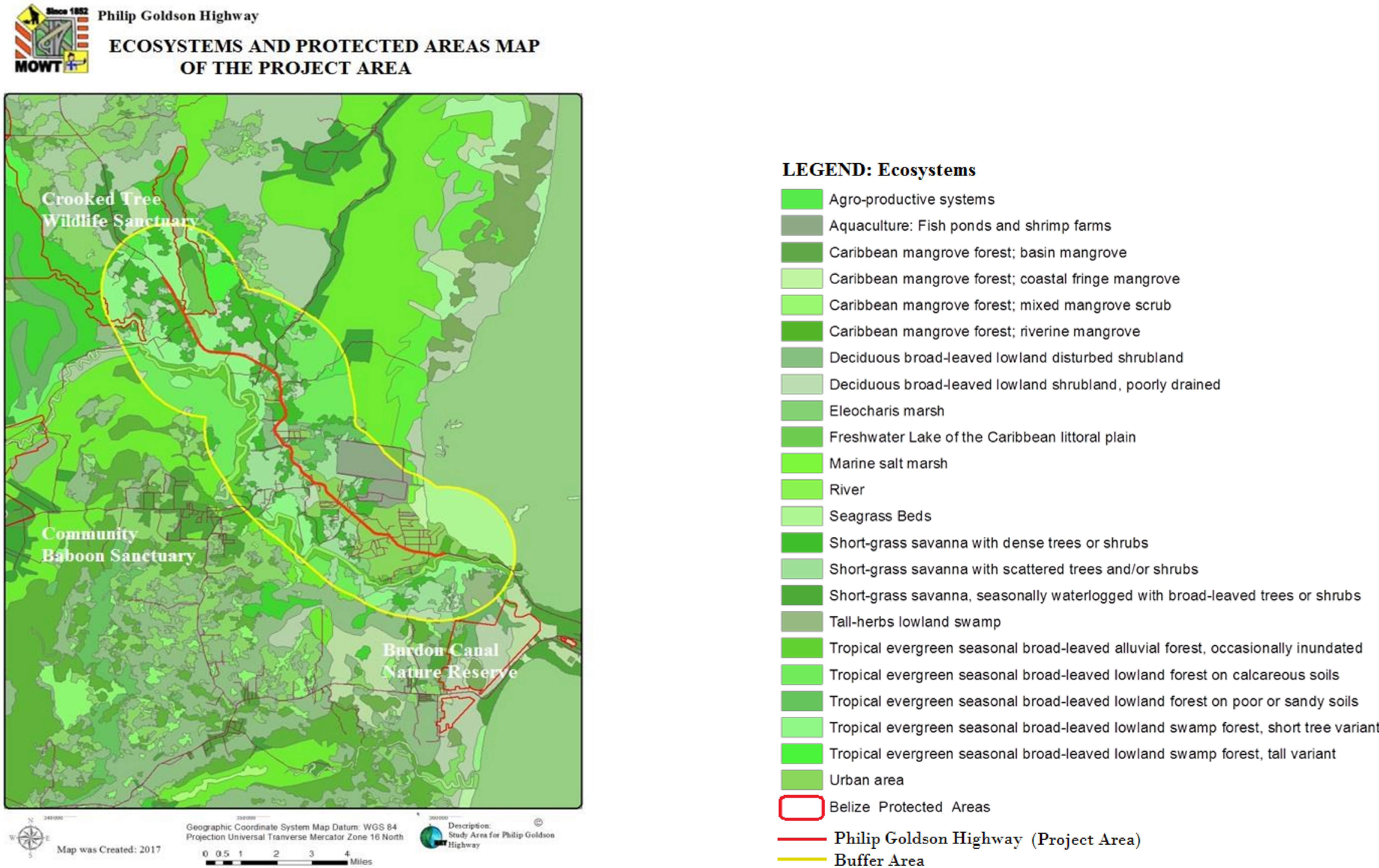


Figure 4.34: Ecosystem and Protected Areas of the Project Area.

Tropical evergreen seasonal broad-leaved lowland forest on poor or sandy soils (UNESCO Code: 1A2a(1)(b)S)

This forest type is represented by two relatively small tracts south-east of Sandhill Village, and by tiny stands in the southern portion of the project area, close to Burdon Canal Nature Reserve. Soils are acidic and nutrient poor, and generally moderately well drained. Common trees include: *Aspidosperma* sp., *Attalea cohune*, *Bactris major*, *Bactris mexicana*, *Bucida buceras*, *Byrsonima crassifolia*, *Calophyllum brasiliense*, *Chrysobalanus icaco*, *Chrysophyllum mexicanum*, *Coccoloba belizensis*, *Desmoncus orthacanthos*, *Guettarda combsii*, *Hampea trilobata*, *Hirtella racemosa*, *Luhea speciosa*, *Metopium brownei*, *Miconia* spp., *Pachira aquatica*, *Pinus caribaea*, *Pouteria* sp., *Psychotria poeppigiana*, *Simarouba glauca*, *Spondias mombi and*, *Tabernaemontana arborea*, *Terminalia amazonia*, *Virola koschnyi*, *Vochysia hondurensis* and *Xylopia frutescens*.

Tropical evergreen seasonal broad-leaved alluvial forest, occasionally inundated (UNESCO Code: 1A2f(2)(a))

Within the project area, this ecosystem is confined to a narrow strip running along the banks of the Belize River. Drainage is relatively poor as compared with that on the calcium-rich alluvium: the soil is seasonally water-logged, with a distinct hog-wallow relief evident in some areas, indicative of seasonal fluctuations between water logging and drought. It is characterized locally by *Aristolochia grandiflora*, *Attalea cohune*, *Bactris major*, *Bactris mexicana*, *Bucida buceras*, *Cassia grandis*, *Cecropia peltata*, *Cordia sp.*, *Costus sp.*, *Enterolobium cyclocarpum*, *Ficus insipida*, *Guadua longifolia*, *Guazuma ulmifolia*, *Heliconia latispatha*, *Inga affinis*, *Lonchocarpus sp.*, *Pachira aquatica*, *Pterocarpus officinalis*, *Roystonea regia*, *Samanea saman*, *Schizolobium parahybum*, *Tabebuia rosea and Trophis racemosa*. Bri bri (*Inga affinis*) is a predominant species on the edge of the riverbanks, and is a preferred food for the endangered Yucatan black howler monkey (*Alouatta pigra).*

Prior to Hurricane Earl, which crossed the area in August, 2016, vegetation was tallest close to the riverbanks, with bullet tree (*Bucida buceras*) reaching over 25m tall. However, following the significant storm damage to the taller trees few now stand over 15m in height in this area. *Acacia collinsii*, *Calathea crotalifera*, *Cecropia peltata*, *Heliconia latispatha*, and

Helicteres guazumifolia are present in the more disturbed areas. Impenetrable thickets of riparian spiny bamboo (*Guadua longifolia*) are present close to the river. Dense stands of cocano boy or pokenoboy (*Bactris major*) are scattered throughout this habitat, generally in areas of hog-wallow relief.

This ecosystem is considered to be under-represented - with the target of inclusion of 17,243 acres within the National Protected Areas System, only 6,825 acres is currently under protection (Meerman, 2005). Because of seasonal agricultural potential, forests on these soils have been heavily impacted by human use throughout Belize. This is clearly evident in the Grace Bank area, where significant tracts have been cleared through to the river to create rough pasture for cattle.

Tropical evergreen seasonal broad-leaved lowland swamp forest, short tree variant (UNESCO Code: 1A2g(1)(a)-Sh)

This ecosystem has a lower canopy than the alluvial forest, and a markedly different species composition – indicative of the much poorer soils away from the nutrient deposition in the alluvial belt. Characteristic species include *Acoelorraphe wrightii, Byrsonima bucidifolia, Calliandra sp., Chrysobalanus icaco, Crescentia cujete, Dalbergia glabra, Helicteres guazumifolia, Miconia sp., Pterocarpus officinalis, Quercus sp. Tabernaemontana alba* and *Xylopia frutescens.* The canopy is broken and patchy, with dense stands of *Acoelorraphe wrightii* varying in height from 3-6m tall, whilst *Byrsonima bucidifolia* and *Quercus sp*. stand up to 8m in height. The latter two species are more characteristic of the short-grass savannah habitat, and their abundance in small patches amongst the more typical swamp forest species represents small areas of marginally (approx. 0.05m) higher elevation. This overall ecosystem can in fact be considered as a micro-mosaic of the lowland swamp forest: low variant and the short-grass savannah with dense trees or shrubs ecosystems. The hog-wallow relief is largely restricted to the former, and the oak and craboo in the latter, only being found in areas without such seasonal inundation indications. Howler monkeys and a jaguarundi were observed in this habitat type during the field assessment.

The complexity of these mosaics poses significant challenges in the mapping of this ecosystem. An area of almost 500 hectares, east of the Highway and just south of Gardenia Village was mapped (Meerman, 2011) as being short-variant lowland swamp forest, when in fact it is better categorized as being predominantly short-grass savannah with dense trees or shrubs interspersed with elements of swamp forest.

Other ecosystems occurring in this area, that were not mapped in the National Ecosystem Map – most likely because of the issues of scale – are examples of tall herbaceous swamp (tall-herbs lowland swamp) just west of the Mussel Creek Bridge, including a near pristine tract of approximately 10 hectares on the southern side of the Highway and another slightly larger area to the north – evidently created anthropogenically some years ago by the clearance of swamp forest / savannah interface vegetation, and which has subsequently become established as an apparently stable herbaceous swamp.

With their large volume of dry-leaf biomass and their proximity to the fire-prone savannah habitat, the patches of tasiste palm (*Acoelorraphe wrightii*) within this ecosystem are very vulnerable to anthropogenic fire in the dry season.

Tropical evergreen seasonal broad-leaved lowland swamp forest, tall variant (UNESCO Code: 1A2g(1)(a)-T)

This ecosystem is highlighted as one of only four terrestrial ecosystems in Belize that are considered as significantly under-represented in the National Protected Areas System, with only 8% protected under the National Protected Areas System (Walker et al., 2013). This does not even meet the 10% minimum level of protection advocated by the IUCN (Meerman, 2005).Currently only 23% of the national target for the protection of this ecosystem is met within Belize’s protected areas. As such, the tract of approximately 450 hectares that lies between Jones Lagoon and the savannah / wetlands mosaic to the east has significant conservation value.

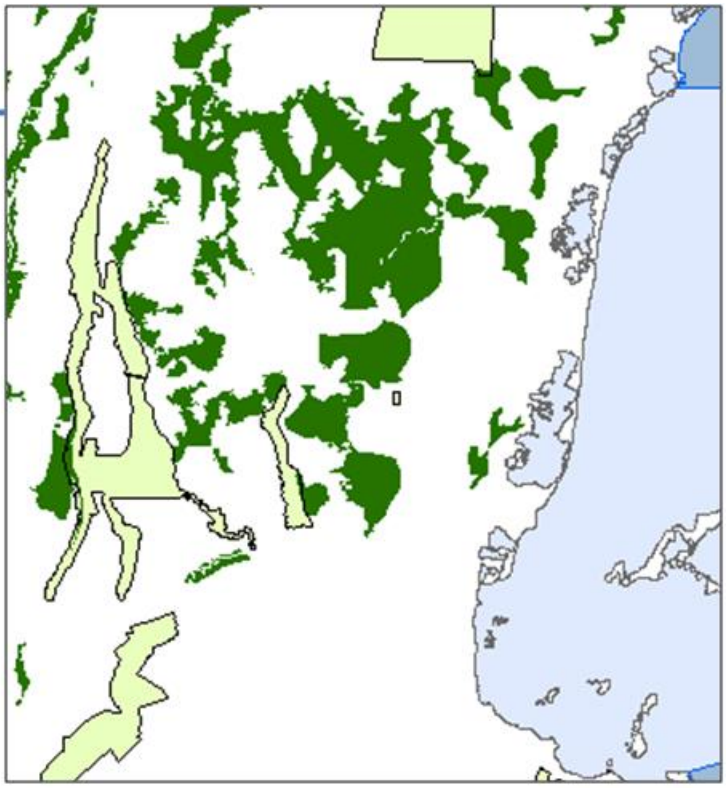


Figure 4.35: Tropical evergreen seasonal broad-leaved lowland swamp forest, tall variant.

The swamp forest in this locality has a relatively high canopy of 15-20m; predominant plant species include: *Bactris major, bucida buceras, Calophyllum brasiliense, Coccoloba belizense, Cryosophila stauracantha, Desmoncus orthacanthos, Ficus sp., Metopium brownei, Pachira aquatica, Pterocarpus officinalis,* and *Swietenia macrophylla.* In more open areas, *Calathea spp.* form small dense stands. The ground is evidently flooded for several months of the year, with very extensive hog-wallow relief – in some areas the 'dry' micro-relief hummocks between the inundated hog-wallows and seepages may represent less than 50% of the overall area.

Caribbean mangrove forest, mixed mangrove scrub (UNESCO Code: 1A5a(1)(c))

Found on slightly less wet soil than most other mangrove ecosystems, mixed mangrove scrub varies significantly in species composition – even over short distances within the same patch. All three mangrove species occur: *Avicennia germinans*, *Laguncularia racemosa*, and *Rhizophora mangle*. Other frequent species include *Acoelorraphe wrightii*, *Acrostichum aureum*, *Conocarpus erectus*, *Myrica cerifera*, and *Rhabdadenia biflora.*

Within the project area, this ecosystem is represented by small tracts just extending within the 4km buffer north and south-east of Ladyville, where the project area is closest to the coast. This ecosystem is considered under-represented within the NPAS, with national protection of only 9.3%.

Caribbean mangrove forest, coastal fringe mangrove (UNESCO Code: 1A5a(1)(d))

This ecosystem is found in generally narrow strips along relatively sheltered coastline, with the characteristic arching stilt roots of the predominant red mangrove (*Rhizophora mangle)* reaching out in to the water. Much of this area grades into mixed mangrove scrub as part of the coastal suite of mangrove ecosystems.

Caribbean mangrove forest riverine mangrove (UNESCO Code: 1A5a(1)(e))

Growing on nutrient-rich alluvium, riverine mangroves occur along the easternmost lower reaches of the Belize River, and can attain an impressive stature, with canopy heights reaching 15+m. The predominant species is red mangrove (*Rhizophora mangle)* with a few specimens of provision bark (*Pachira aquatica*) and kaway (*Pterocarpus officinalis*). This ecosystem is significantly under-represented within the protected areas of Belize, with only 11% of national coverage protected within the National Protected Areas System (Walker et al. 2013).

Caribbean mangrove forest, basin mangrove (UNESCO Code: 1A5a(1)(f))

Generally occurring on waterlogged peaty soils, this ecosystem is dominated by tall red mangroves (*Rhizophora mangle)*, varying in height depending upon inundation cycles and nutrient availability. Where water depth is less and tidal flushing, amplitude, and kinetic energy of floodwaters decrease, other mangrove species and associates invade. Where salinity reaches levels above 50 %, *Avicennia germinans* dominates. In addition to being highly saline, the soils may be very anaerobic, giving the *Avicennia* an ecological advantage through its pneumatophores. Where salinity is about 30-40 %, a more diverse species composition occurs, with dominant species including *Avicennia germinans*, *Laguncularia racemosa*, and *Rhizophora mangle*. When the ecosystem is degraded, particularly by fire, the fern *Acrostichum aureum* becomes the dominant species.

An impressive tract of tall basin mangrove stretches along much of Haulover Creek to the east of the project area, extending into the south-eastern-most portion of the buffer area.

Deciduous broad-leaved lowland disturbed shrub land (UNESCO Code: IIIB1b(a)2)

Found on poorly drained sandy soils overlying sandy clay, there is very little vertical water movement through the soil, with most water movement being lateral sheet drainage. It is frequently exposed to fire during the dry season. Dominant species include *Agarista* sp., *Curatella americana*, *Byrsonima crassifolia*, *Pinus caribaea*, *Quercus* sp. Herbs are *Andropogon* spp., *Cyperus* spp, Panicum *spp.*, *S. parviflora*, *Setaria tenax*, Scleria *ciliata*, *Sporobolus indicus*, and *Trachypogon sp.* Within the project area, it is represented by an extensive tract in the Double Run area west of the road, and by smaller patches to the east. In this area, the habitat is the result of the severe degradation of short grass savannah habitats.

Deciduous broad-leaved lowland shrubland, poorly drained (UNESCO Code: IIIA1b(a))

Scattered across the savannah habitats within the project area, this ecosystem is largely the result of fire damage to the original savannah habitats. It overlaps the lowland disturbed shrubland significantly in species composition and structure in this area and the two are probably best considered as one system.

River (UNESCO Code: SA1a)

The Belize River and its tributaries, Mussel Creek, Black Creek, and Mexico Creek are described in detail under the limnological section of this assessment. Once home to significant populations of aquatic vertebrates such as the Critically Endangered hicatee and the Neotropical river otter, both species have declined significantly in recent decades as a result of unsustainable hunting pressure, with the low-visibility deep waters of Black Creek now offering some degree of protection against mostly illegal hicatee harvesting.

Freshwater lake of the Caribbean littoral plain (UNESCO Code: SA1b(4)(b))

Freshwater lakes are scattered across the landscape of the northern and central sections of the project area, ranging in size from small ephemeral ponds to the expansive Jones Lagoon that lies within the easternmost portion of Crooked Tree Wildlife Sanctuary. Jones Lagoon itself falls entirely within the road buffer area.

These freshwater lakes vary in their vegetation depending on a number of factors, including seasonal fluctuations in water level, flushing, and nutrient levels. Many have *Eleocharis spp*.

extending throughout the shallows, often bordered by *Typha domingensis* cattails. The large floating leaves of water lilies, *Nymphaea spp.* provide foraging habitat for northern jacanas (Figure 4.36).

These freshwater lakes are critical feeding grounds for Belize's wading and wetland birds, with species such as the American wood stork flying tens of kilometres between coastal nesting colonies and the lakes, whilst others live year-round within these wetlands.

Figure 4.36: Water Lilly at Jones Lagoon.

Short-grass savannah with scattered trees and/or shrubs (UNESCO Code: VA2a(1)(2))

Short-grass savannah with shrubs is a complex mosaic of species assemblages, each reflecting micro-topography, soil hydrology, soil acidity & nutrient availability, fire regime and seed source. In this locality, much of the short-grass savannah is open grassland. *Cameraria latifolia, Chrysobalanus icaco, Curatella americana, Gliricidia sepium* and *Quercus oleoides* occur at low density throughout much of the system, often as dwarfed specimens regenerating from past fires. Lower areas that are more frequently inundated often support stands of *Acoelorraphe wrightii*, or *Eleocharis sp.* – the latter being afforded its own ecosystem categorization under the UNESCO classification (discussion under 'Eleocharis marsh').

This ecosystem is transitional from short-grass savannahs to tropical evergreen seasonal needle-leaf lowland dense forest (Meerman, 2005) and results from fire damage to the latter (Figure 4.37). *Pinus caribaea* is scattered across the landscape, and other common trees and shrubs include *Acoelorrhaphe wrightii, Byrsonima crassifolia, Chrysobalanus icaco, Cresentia cujete, Curatela americana, Hirtella racemosa, Quercus oleoides,* and *Xylopia frutescens.*

The dense clay subsoil largely prevents vertical drainage of surface water from the topsoil. As a result, the topsoil is often waterlogged in the wet season, and extremely dry in the dry season. Because of these seasonally very xeric conditions, this ecosystem is very vulnerable to dry season fires, and anthropogenic fire is an annual threat, generally depressing species diversity and interrupting the development of a rather more woodland structure.

Figure 4.37: Short-grass savannah with scattered trees and/or shrubs.

Actual coverage is dynamic, and is increased over historical extent as a result of anthropogenic fire. Pines previously occurred over a larger portion of this savannah ecosystem than is currently the case.

With much of this ecosystem being a degraded form of the pine savannah that is itself a threatened system, active conservation management (including fire awareness, prevention, and active fire management) and habitat restoration programmes should ideally be implemented within this savannah and shrub land system. Restoration of the *Pinus caribaea* population and range should be a priority, bringing with it the likely restoration of nesting and feeding habitat for the endangered yellow-headed parrot.

Short-grass savannah with dense trees or shrubs (UNESCO Code: VA2a(1)(g))

The complexity of these mosaics poses significant challenges in the mapping of habitats: an area of almost 500 hectares east of the road and just south of Gardenia Village was mapped as being short-variant lowland swamp forest, when in fact it is better categorized as being predominantly short-grass savannah with dense trees or shrubs interspersed with elements of swamp forest.

Common tree and shrub species of this ecosystem include: *Acoelorraphe wrightii, Calyptranthus* sp., *Cameraria latifolia, Chrysobalanus icaco, Clidemia* sp., *Crescentia cujete, Curatela americana, Erythroxylum guatemalense, Gliricidia sepium, Hippocratea excelsa, Metopium brownei, Miconia* sp., *Mimosa albicans, Pinus caribaea*, and *Quercus oleoides.*

Eleocharis marsh (UNESCO Code: VD1a(1))

This ecosystem occurs predominantly in waterlogged or flooded hollows in the short-grass savannah. Generally the extent of each patch is too small to be mapped (as was the case for the Belize Ecosystems Map), and as a result, it is highlighted as an under-represented ecosystem within the NPAS, with only 9.3% mapped as under protection (Walker et al., 2013). However, it should also be recognized that current levels of mapping resolution are too course to adequately demonstrate the true extent of this system – either inside or outside protected areas.

Eleocharis reeds form an almost mono-specific community, with only very low-density occurrence of other herbaceous species. In the context of the area, these *Eleocharis* marshes are notable for the seasonal presence of jabiru storks, and other wading birds, and play a role in the management of storm event flood waters. Whilst these reed marshes are afforded their own categorization under the UNESCO classification system, they would perhaps be better considered as a species assemblage within the short-grass savannah ecosystem.

Where frequent or permanent inundation occurs, *Eleocharis* spp. is usually present (Figure 4.38).

Figure 4.38: Eleocharis marsh.

Marine salt marsh (UNESCO Code: VE1a(1))

This community type occurs in marshes in the coastal plains where the salinity level is high - generally greater than 5%. This community is highly heterogeneous and contains patches dominated by different species with varying levels of salt tolerance, which are all taken together here to indicate one main salt marsh community type.

Common dominants in the vegetation are *Batis maritima*, *Distichlis spicata*, *Fimbristylis spadicea*, Juncus spp., *Salicornia bigelovii, Solanum sp.*, and *Spartina spatinae.* Flats with these principally herbaceous species may contain stunted *Conocarpus erecta* and dwarf *Rhizophora mangle*. Slightly elevated areas in this type of marsh contain forest species such as *Bravaisa tubiflora*, *Metopium brownei*, *Manilkara zapota*, and *Thrinax radiata.*

Tall-herbs lowland swamp (UNESCO Code: VIIB4)

The vegetation in this ecosystem stands up to 2-3m tall, and includes an assortment of grasses, sedges, herbaceous broadleaved plants, and woody shrubs. Species observed include *Dalbergia glabra, Eleocharis sp., Hymenocallis littoralis, Maranta arundinacea, Mimosa tarda,* and *Rhynchospora cephalotes and Typha dominguensis* – the southern cattail.

Figure 4.39: Tall herbaceous swamp – centre, *Eleocharis* marsh in foreground.

Tall herbaceous swamps (Figure 4.39) are often limited in extent, and are therefore under-represented the habitat mapping at the scale of the National Ecosystem Map (Meerman, 2005). An excellent example of this ecosystem is located just west of the Mussel Creek Bridge a near pristine tract of approximately 10 hectares on the southern side of the road, and another slightly larger area to the north – evidently created some years ago anthropogenically by the clearance of swamp forest / savannah interface vegetation, and which has subsequently become established as an apparently stable herbaceous swamp. Other examples are found east of the Burrell Boom junction, in association with extensive *Eleocharis* marshes.

Seagrass beds (UNESCO Code: VIIIA)

The seagrass beds off the coast from Ladyville include *Halodule wrightii*, *Syringodium filiforme*, and *Thalassia testudinum,* and are recognized as critical feeding grounds for the largest sub-population of the Endangered Antillean manatee in Belize (Galves, J., pers. com.).

Agro-productive systems (UNESCO Code: SPA)

Because of the limited agricultural value of most of the soils within the project area, there is only a limited large-scale agricultural footprint – with farmlands mostly used for rough pasture for cattle or sheep. These are mostly based in areas that are subjected to some degree of seasonal flooding and which therefore benefit from the occasional deposition of alluvial sediments bearing rather higher nutrient levels. At a small holding scale, there are productive areas of permanent fruit trees – primarily within the overall footprint of rural villages.

Aquaculture: Fish ponds and shrimp farms (UNESCO Code: SPC1)

Shrimp farming was once a significant industry and employer within the Ladyville area, with the (now dissolved) Nova Shrimp Farm encompassing approximately 1,100 hectares of productive shrimp ponds. Owing to a number of factors, including disease and falling world prices, Nova ceased production several years ago and the ponds now lie largely unused – over 80% of which lie within the road buffer area. These provide foraging areas for water birds and Morelet's crocodile.

Urban area (UNESCO Code: U1)

The communities of Ladyville, Sandhill, Grace Bank and Gardenia are described more fully in the socio-economic sections of this assessment. It is however noteworthy that, with the exception of Ladyville, housing densities are low, with the other villages retaining some biodiversity value and retaining some degree of the ecosystem services provided by the former natural habitats.

4.9.2 Ecosystem Services

4.9.2.1 Provisioning Services

Water Catchment / Supply

The wetlands within the project area provide critical water catchment and containment functionality for the area, though the mechanical processes of surface water movements have been impaired by roads, buildings, walls, landfill, etc., that have not adequately addressed the need for surface water movement through and across the landscape. The Philip Goldson Highway acts as a dam along much of its length, with over-run being observed occasionally within the section to be upgraded and further to the North in the Mile 42 section. The ability of the wetlands to act as a sink, not only for the rainwater falling in the area, but for the vastly greater volume of water entering the system from higher in the watershed during storm events (see the section on flood mitigation below), and then release it back into the Belize River as the floodwaters recede dramatically reduces the exposure of Belize City to severe flood impacts during storm events.

Timber and NTFP resources

Timber

Historically the pine savannahs within the study area were a source of quality pine lumber that was once more significant than the modest quantities of hardwoods harvested from the adjacent broadleaf forest. Unsustainable logging and frequent anthropogenic fires over many decades have however altered the pine savannah ecosystem, significantly reducing the density and size classes of both the pine and associated tree species, with few trees of harvestable size remaining within the project area. Implementation of effective fire management could result in significant habitat rehabilitation – and with it the restoration of timber production services.

Non-timber forest products

Numerous non-timber forest products (NTFPs) are harvested locally, including thatch leaf (*Sabal mauritiformis*), tasiste (*Accoeloraphe wrightii*), fence posts of various species including *Gliricidia sepium* and *Caesalpinia yucatanensis*, roofing poles (including *Aspidosperma megalocarpon* and *Simarouba glauca*), and medicinal plants such as contribo (*Aristolochia grandiflora*).

Game species

Given the age and history of several of the rural communities in the area, and the persisting low income, it is not surprising that many game species are hunted, and remain an important part of day to day life, playing a significant role in the cultural identity of the older communities. Species hunted for meat include the Central American river turtle (or hicatee), paca, armadillo, white-tailed and brocket deer, collared peccary, curassow, guan and iguana. Hunting is normally concentrated during flood times, when game species retreat to higher patches of broadleaved forest. With the combined impacts of the increasing frequency of storm events and the removal of broadleaved forest, pressures on the game species are increasing, and game species populations are considered to have declined significantly, with an urgent need to improve regulation of hunting in the area (Forest Dept., pers. com.). White lipped peccary, a key indicator species of hunting pressure, whilst present historically, disappeared from the area by 2004 (Walker et al., 2004).

Fish

Fish are culturally important for all communities within the project area and fishing is used as a means to supplement protein. A pre-*Tilapia* stock assessment of the Crooked Tree fishery, carried out in 1985, gives a broad baseline assessment of the three major fisheries species of the wetland system of the project area (Meekin, 1985). Studies of net and line catches in 1985 showed that the three most commonly caught species were *Petenia splendida*, *Cichlasoma uropthalmus* and *Cichlasoma freidrichsthali* – which continue to be preferred today. Following the appearance of the invasive Tilapia (*Oreochromis niloticus*) in 1985, there has been a shift towards use of this species, which rapidly out-competed the native species in use of the resources. Since then, however, the system has become somewhat more balanced, with a gradual return of the preferred native species, and fishing of both continues.

Fishing pressure intensifies towards the middle of dry season, as the water flows out of the lagoons, and the rivers and creeks start to dry up, making fishing easier. Maintenance of the annual changes in water flow are critical to not only the lives of the fish, but also of the fishermen in the project area.

Genetic resources bank

The mosaic of habitats within the landscape of this area harbours a high diversity of flora and fauna, many of which are harvested for human use. Whilst many of these are relatively ubiquitous species occurring across much of the coastal plain, several plant species are endemic to these savannahs and greatly boost not only the conservation importance of them but also their value as a gene bank for these endemics.

4.9.2.2 Regulating Services

Water Quality

Natural vegetation cover – riparian and swamp forests, savannahs and wetlands, play critical roles in the maintenance of water quality in the Belize River and its tributaries, stabilising soils, reducing sediment run-off, filtering pollutants, etc. Given the scale of unofficial dumps that are scattered across the project area, such as the one depicted in Figure 4.40, photographed in the Los Lagos /

Figure 4.40: Cocunt husks dumped on the road side.

Ladyville area, the risk of significant pollution of surface, ground and river waters is considerable. Given the extraction of water from the Belize River for treatment to supply Belize City, Ladyville and other communities, such unofficial, unregulated and contaminating dumping is extremely hazardous. The natural vegetation cover will help significantly in slowing surface run-off and filtering pollutants, but cannot be expected to fully mitigate the impacts when solid waste dumping is on this scale.

The functionality of some ecosystems in the maintenance of water quality is also largely removed in some areas, such as the Grace Bank area where riparian forest has been completely cleared to the water to provide access to water for cattle in rough pasture (Figure 4.4.1). This is in contravention of the policies of both the Lands Department and the Department of the Environment, but is often unenforced.

Figure 4.41: Riparian forest removed at Grace bank.

Climate Change Mitigation

Carbon sequestration

The scale and functionality of carbon sequestration services provided by the ecosystems within the project area are severely impacted by the frequent anthropogenic fires that occur annually throughout much of the savannahs. For an approximation of potential, given effective on the ground fire management, the Laguna Seca Forest Carbon Project VCS Verification Report (Environmental Services, 2016) provides the closest and most relevant data. As a result of the uncontrolled anthropogenic fires that sweep through the savannahs in this year each year, vast quantities of sequestered carbon and smoke particles are released into the atmosphere during each fire.

Flood Control / buffer

The wetlands of the Crooked Tree Wildlife Sanctuary area, and the interconnected creeks and savannahs that lie within the buffer area of the road section to be upgraded play a critical role in flood mitigation for Belize City, protecting life and property from significant annual flood risk (Walker et al., 2004).

Crooked Tree Wildlife Sanctuary lies within the Belize River Watershed, the largest of twenty-nine watersheds identified in Belize (Belize Environmental Profile, unpublished). It originates in the western slopes of the Maya Mountain, draining the Chiquibul and Vaca Plateau areas, and in eastern Guatemala. A complex drainage area of an estimated 6,356.7km², the Belize River Watershed can be divided into four major sub-basins.

The project area lies within the fourth sub-basin, the Lower Belize River, where the river slows down, entering the floodplain, and meandering through this final stretch, draining an estimated 1445.1km² before reaching the sea. Crooked Tree a significant component of this sub-basin, acts as part of a huge water storage area for the Belize River when it is in flood. When extensive storm-generated rainfall causes high-stage floods, water is forced backwards up Black Creek and into the Crooked Tree wetland complex of Northern, Western, and Revenge Lagoons, filling the inundation area, then flooding the adjacent pine savannah, and backing up Spanish Creek. Once the river flow is back to normal, the stored water then drains back into the river through Black Creek (Figure 4.42).

Mexican and Jones Lagoons – the eastern section of Crooked Tree Wildlife Sanctuary, act as a flood storage area in a similar way to the main lagoon system, with water backing up Mexico Creek during storm events to flood the two water pans and surrounding savannahs. Once the Belize River falls, the stored water is released more slowly through Mexico Creek.

Clean Air

Natural tropical ecosystems are often referred to as the lungs of the planet – soaking up vast quantities of carbon dioxide and releasing the oxygen needed by all living creatures. Plants, particularly pines, are also known to absorb and sequester a wide range of airborne pollutants, contributing further to the critical ecosystem service of the provision of clean air. This very positive output is however tempered in this location by the frequent anthropogenic fires that sweep across the savannahs each year – releasing huge volumes of greenhouse gasses, smoke particles and other pollutants back into the atmosphere.

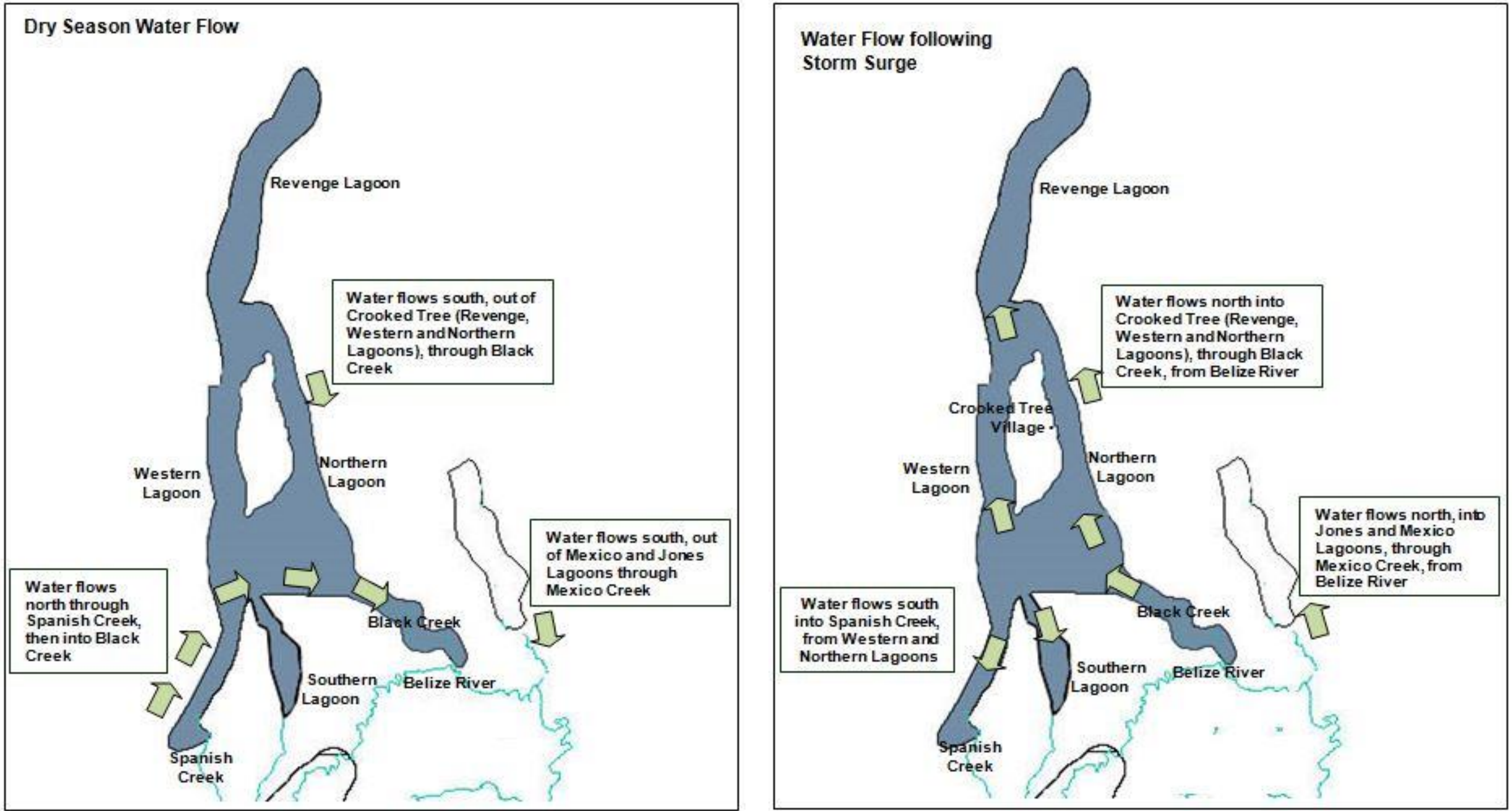


Figure 4.42: Water flow during Dry Season and Wet Season.

4.9.2.3 Cultural Services

Aesthetic Values – vistas, tourism values

The scenic value of these savannahs, with the lush broadleaf forests as a backdrop are appreciated not only be the large number of Belizeans travelling the Philip Goldson Highway daily, but also by the significant volume of international tourism travelling the same route on the way to the Lamanai Archaeological Reserve, or taking boat trips up the Belize River to Burrell Boom and the Community Baboon Sanctuary.

Crooked Tree Wildlife Sanctuary, as a RAMSAR site, provides a tourism resource for nature tourism, especially in dry season when low water levels result in thousands of water birds congregating in the receding waters. The tourism values of the aesthetic beauty of the Wildlife Sanctuary and its wildlife provide economic benefits to the Crooked Tree community.

Education / Research

The project area has not been of significant value as an education / research venue, except for Crooked Tree Wildlife Sanctuary, though has been included in wider, national level research projects. The most significant research in recent year in this area was undertaken as part of a wider assessment of lowland savannahs in a collaborative Darwin Initiative Project conducted by a group from the University of Edinburgh and the Environmental Research Institute of the University of Belize. This Savannah Ecosystem Assessment developed higher resolution mapping of lowland savannahs and developed the most up to date validated checklist of the vascular plants found therein (Goodwin, et al., 2013).

4.9.2.4 Supporting Services

Soil formation / retention / erosion control

Tropical ecosystems play a central role in soil formation and retention, from the action of root activity in breaking bedrock surfaces, accessing minerals and binding loose material, to maintaining adding organic content through the decomposition cycle. The biotic processes taking place within the soils in turn support the forests and savannahs and the primary productivity that forms the base of the food web. Vegetation loss (through land use change) or degradation (resulting from anthropogenic fire) can lead to rapid loss of surface soils, leading to reduced ecosystem functionality, decreased water retention capacity, increased surface run-off, erosion and sediment flow into waterways.

4.9.3 Protected Areas

Three protected areas lie within the proximal landscape through which the Philip Goldson Highway passes (Figure 4.43). The largest, Crooked Tree Wildlife Sanctuary, is internationally recognized as a RAMSAR wetland site, and has two portions falling within the 4km buffer of the road section to be upgraded: the Black Creek portion lies within 2.4km of the road and the eastern portion covering Jones Lagoon reaches right up to the Mussel Creek Bridge. The Mussel Creek portion is very susceptible to impacts from the road because of the two-way flow of water as described above.

Figure 4.43: Protected Areas Surrounding the PGH Upgrade Section. Google Earth Image.

Burdon Canal Nature Reserve lies immediately south-east of the road buffer, though is more directly exposed to impacts from the George Price Highway and the westernmost developments of Belize City. At its closest, the north-eastern tip of the Community Baboon Sanctuary lies within approximately 5.5km for the road buffer and, lying upstream, is largely isolated from direct impacts from the road. Similarly the Altun Ha Archaeological Reserve, lying almost 8km from the buffer area, is considered largely isolated from direct impacts from the road.

4.9.3.1 Crooked Tree Wildlife Sanctuary

Size: 22,812 acres (9,231 ha)

IUCN Category: IV (Recommended change to VI to recognise local traditional fishing rights)

Management Authority: Forest Department

Co-Manager: Belize Audubon Society

Established in 1994 to "maintain biological integrity and traditional cultural resources within a functional conservation area, as an effective RAMSAR site". The Wildlife Sanctuary surrounds Crooked Tree Village, one of the oldest rural communities in Belize, and culturally tied to the natural resources – both through hunting and fishing.

Crooked Tree Wildlife Sanctuary is a core component of the North East Corridor, and a RAMSAR site important for water birds. A population of the critically endangered Central American river turtle (hicatee) is still present.

The wetland system is adapted to fluctuate between flood and drought condition. The natural aquatic life is already seriously compromised by the presence of Tilapia. This species may be more adaptable to predicted changes, and provide local community members with continued access to fish. Increased resilience will rely on the maintenance of flood sink functionality, protecting Crooked Tree, as well as Belize City and other communities downstream, and effective management of fire impacts on savannah.

4.9.3.2 Burdon Canal Nature Reserve

Size: 4,314 acres (1,745 ha)

IUCN Category: Ia

Management Authority: Forest Department

Established for the protection of its extensive mangroves and the land stabilization / flood control they provide for Belize City.

Burdon Canal Nature Reserve plays a very important flood control role for Belize City and provides significant storm surge protection. It protects significant mangrove habitat and water birds.

4.9.3.3Community Baboon Sanctuary

Size: 9,983 acres (4,040ha)

IUCN Category: IV

Management Authority: Forest Department / Privately Protected Area

One of the first Privately Protected Areas in Belize established in 1985 more as a Land Management Tool under an agreement amongst landowners to leave habitat connectivity for the protection of the endangered Yucatan black howler monkey.

4.9.4 Water Bodies of the Study Area

4.9.4.1 The Belize River

Several major water bodies dominate and define the project area. Intersecting the project area about 3.0 km south-southeast of the northern end, the Belize River roughly parallels the PGH, lying between 0.6 km to 5.3 km westward of the highway (Figure 4.44). Following the river from its intersection with the project site at 17^{o}39’52.00”N by 88^{o}26’00.79”W, and using that as a starting point, the river meanders about 50.4 km to the southern boundary at the PGIA. This lower reach section of the Belize River drains a 10,500 km^2 watershed, a third of which lies in Guatemala and home to over 100,000 Guatemalans, while 140,000 Belizeans live in the two thirds within Belize (see Boles, 2016). These waters flow past many farms, and through many urban areas. The Belize River carries water, sediments, dissolved minerals, nutrients, particulate and dissolved organic matter, and energy to the coastal zone waters. It also carries pollutants, from manure and human sewage to chemicals (pesticides, oil, and grease) through the project site and into marine environments.

Figure 4.44: Drone view of the Belize river above Grace Bank and Davis Bank area. Pasture land on both banks of the river. ☆ Mussel Creek confluence with the Belize River.

Three blackwater streams (streams that have wetlands as headwaters, typical of small stream systems that originate within lower reach floodplains) also occur within the project site. Blackwater streams are often the colour of strong tea, being heavily laden with dissolved tannins and other compounds leached out of plant material decomposing within wetlands.

4.9.4.2 Black Creek and Crooked Tree Lagoons

Black Creek, obviously named for the colour of its waters, flows out of the rich Northern Lagoon wetland ecosystem within the Crooked Tree Wildlife Sanctuary (CTWS). On the current 2016 Google Earth© image the dark waters of Black Creek can be seen discharging into the much lighter waters of the Belize River, and running parallel with the flow until the two water masses gradually mix further downstream (Figure 4.45).

Figure 4.45: (Left) Black Creek above Wash Pan area. (Right) Black Creek can be seen discharging into the much lighter waters of the Belize River (Google Earth, 2017).

The Northern Lagoon (also call Crooked Tree Lagoon), and all of the small creeks and wetlands draining into it connects to the Belize River through Black Creek just upstream from Compass Point. The Crooked Tree Wildlife Sanctuary, including Northern Lagoon and part of Black Creek, includes very productive lagoon/wetland systems, a dynamic patchwork of permanent and seasonally shallow freshwater lagoons, swamps, marshes, and stream and river reaches. These wetlands and lagoons can become very shallow, with some water bodies drying up completely in the dry season (March to May). Deeper portions of the lagoons may have wet season depths up to 3 m. This very productive wetland ecosystem harbours abundant producers, including pastures of submerged aquatic plants and algae within the lagoons, swamp forests of logwood (*Haematoxylon campechianum*), the largest remaining stands in Belize, Calabash (*Crescentia cujete*), and mimosa (*Mimosa pigra*), large areas of sedge (*Eleocharis interstincta*) and grass marshes, thick patches of lilies, inundated savannahs, and riparian forest, especially along Black Creek. The plant and algae biomass, both as living tissue and detritus, supports an abundance of aquatic invertebrates, that in turn provide for a rich fish fauna, that ultimately feed a large diversity of wildlife, with birds representing the greatest numbers of non-fish vertebrate wildlife species and numbers of individuals.

In the wet season water level rises significantly within the CTWS lagoons, particularly when the Belize River is in flood stage, with wetlands around the margins of the lagoons extending far into the savannah landscape. When the Belize River is rising, water backs up into Northern Lagoon, flowing upstream through Black Creek, into Mexico Lagoon and Jones Lagoon through Mexico Creek, and presumably into the wetlands of Mussel Creek through that stream (Figure 4.46). As the river stage falls, water drains back into the Belize River through Black Creek. This stream is also used as access to Northern lagoon during high water periods by jacks, Atlantic Tarpon (*Megalops atlanticus*), and West Indian Manatee (*Trichechus manatus*).

Riparian forests along the lower reach of Black Creek lying within the PGH project site are well developed but show some signs of storm damage. Wood in the water is significant, probably related to Hurricane Earl, but is not obstructive to canoe passage, and helps provide habitat for periphyton, fishes and macro invertebrates. Banks are often steep with many well developed undercut banks where the flowing water has carved out the sediment beneath thick root mats of riparian trees and shrubs (often good macro invertebrate habitat). Limestone occurs in the creek further upstream, providing additional habitat area.

Figure 4.46: Mussel Creek half a mile before the Belize River confluence.

When examined on Google Earth© and during field excursions, Black Creek shows relatively minimal impacts or obvious issues. This stream flows out of a protected area, and is itself partially protected (its upper end). Of course hunting and fishing occur in the creek and wildlife is likely impacted (personal communication with a local man calling his hunting dog from the bridge). One small residence about 0.5 km upstream of the bridge had a boat tied to a board dock. The bridge itself, crossing Black Creek just 0.34 km upstream of its confluence with the Belize River, is a wooden structure that is or was in the process of being replaced by a concrete bridge. The approach to the current bridge has recently been fortified with new loads of sand and gravel and compacted with heavy machinery (some impact from sedimentation probably affecting the stream). Large steel and concrete pilings have been put into place, but work on the bridge came to a halt some time ago.

4.9.4.3 Mussel Creek

Mussel Creek is a blackwater stream flowing out of a wetland that includes Cox Lagoon and other lagoon/wetland areas accessed from the George Price Highway through Big Falls Ranch. It intersects the Belize River from its right bank about 6.0 km downstream of the mouth of Black Creek that enters from the left bank and about 0.8 km upstream of where Mexico Creek enters the Belize River, also from its left bank. Trees canopy the unimpacted reaches of Mussel Creek in many places. The stream has a sandy to limestone/marl bottom covered by leaves and wood. The banks are relatively steep, many edges being undercut with heavy amounts of fibrous root material submerged or recently exposed as water levels recede in the dry season (habitat space for macro invertebrates). The lower end of this stream contains a significant amount of wood, possibly from storm damage. A canoe passage had been opened through some fallen trees with a chain saw, indicating frequent use of the area, probably by local people. There are many snags within the water that obstruct flow, promoting built up of floating detritus mats. Occasional patches of floating aquatic plants, Water Fern (*Salvania auriculata*) and Water Cabbage (*Pistia stratiotes*), are found in small numbers within detritus mats, possibly occurring in much larger amounts within lagoons upstream. One lone howler monkey was seen foraging at about eye level during the field expedition.

Mussel Creek has the most significant impact of these two blackwater streams, with 0.97 km of its right bank riparian forest, just above its junction with the Belize River, having been cleared or badly thinned to give cattle access to the water. This same rancher has also cleared the Belize River right bank downstream of the Mussel Creek confluence and around the inside of the meander for an additional 1.38 km, giving a total of 2.35 km of riparian forests impacted, the longest stretch of impacted riparian forest in the study site based on Google Earth© 2016 imagery. Besides riparian deforestation, Mussel Creek is probably also used by local fishers and hunters.

4.9.4.4 Mexico Creek and Jones and Mexico Lagoons

The smaller Mexico and Jones Lagoons are located east of the Northern Highway (Figure 4.47) and discharge into the Belize River downstream of Grace Bank through Mexico Creek. Jones Lagoon forms part of a small savannah/wetland system that, together with Mexico Lagoon on its northern end, is roughly 567 hectares (1,400 acres) in size (Ramsar, 2000). Mexico Lagoon tends to get very low or almost dry up in extreme years, being largely a marsh/wetland area. Jones Lagoon is a much larger, more open, and shallow lagoon surrounded by wetlands.

Figure 4.47: Jones Lagoon (South-Eastern) empting into Mexico Creek.

The Jones Lagoon is very different from those lagoons on the western side of the highway. There is very little emergent vegetation along the shoreline. Much of the sediment of this lagoon is covered by a loose bed of crumbly to thin layer of algae, cyanobacteria, small submerged sedges and other associated organisms. Interspersed within the loose algae crumbs are scattered patches of submerged aquatic plants.

In dry periods, many fishes in these lagoons area are trapped in shrinking water bodies, and experience higher mortality rates as water quality degrades. Fishermen describe thousands of dying fishes bodies floating on the surface of the water, adding to poor water quality conditions and increasing the stress imposed on surviving aquatic life. This seems to be especially characteristic of Jones Lagoon, where there are a lot of fishes, but relatively few wading birds and other predators gather to feed on these concentrated fishes, as compared to the larger Northern Lagoons on the western side of the highway (Mr. Steve Tillett, personal communication). Fishers also state that in the dry season those fishes that do survive can become infested with parasitic worms growing under their scales.

The Mexico Lagoon/Jones Lagoon area has been proposed as a link for the Northern Biological Corridor, which forms part of the larger regional Meso-American Biological Corridor. The Biscayne Corridor connects the Belize River Node to the Esteves Node that incorporates Jones Lagoon. This defined strip is too narrow to be a main corridor, but could serve as a support corridor. The area includes a significant amount of agriculture and private lands, requiring the development of a close working relationship with buffer communities, particularly in maintaining the PGH Crossing. The traffic in this crossing, linking Mexico and Jones Lagoons to protected areas on the other side of the highway, is a serious threat to wildlife using this corridor (Meerman, et al., 2000).

4.9.4.5 Importance of the Lagoons in Study Area

The lagoons in the study area are wide water bodies with streams meandering through them, being more apparent in dry seasons when water levels get very low. Water movement through widened stream sections large enough to form lagoons is very much slower than that moving through narrow streams, allowing fine particles of materials to settle, adding to thick sediment layers. Jones lagoon is covered in fine sediment below the loose cover of algae, and the dark anaerobic zone lies a few centimetres or less below the thin surface layer. Organic material buried within the anaerobic sediments break down very slowly if at all, making wetlands in general important storage sites for organic carbon as detritus or peat over geologic time.

This lagoon/wetland system, along with the headwater lagoon/wetland system of Black Creek, are vital components of the Belize River watershed, providing many important ecological services such as nutrient rich habitats that provide nursery areas for larval and juvenile aquatic organisms in high water periods. These wetlands produce large amounts of plant detritus during the high-water period, much of which is processed and exported to connected ecosystem types downstream. During low-water season, as wetlands dry up and water bodies recede, wetland sediments become wetland soils, often supporting fast growth of terrestrial and semi-aquatic sedges and grasses browsed by terrestrial fauna.

Wetlands also provide diverse habitat for wildlife of many kinds, contributing to biodiversity of the landscape. Wetland areas often occur in mid to low reaches of watershed systems, differing in size, structure and plant community composition from upstream to downstream. Evidence of all these ecological services can be observed in the PGH project area by the presence of top aquatic and terrestrial predators. During the field surveys skeletons of Morelet's Crocodile (*Crocodylus moreletii*) were noted beside Mexico Creek just upstream from the PGH Mexico Bridge, and paw prints of a Jaguar (*Panthera onca*) were seen on the south-eastern shore of Jones Lagoon. Other wetlands and streams in the area are also noted for crocodiles and other wildlife, indicating the rich biodiversity of the area.

All the wetlands within the PGH project site and those wetlands and lagoons servicing the Belize River Watershed are vital to the watershed community, especially those communities and businesses downstream. During high rainfall and high flow conditions within the Belize River, these wetlands absorb and temporarily store large amounts of floodwater, releasing this water back into river systems as river stages fall. This helps to reduce the magnitude of flood events within a watershed system. They hold water for long periods of time, allowing some of it to slowly infiltrate geologic layers and help recharge aquifers. Within the Northern and Western Lagoon areas, this function has been greatly impeded by GOB-built causeways, this function partially restored by notching the causeway across Northern Lagoon with bridges, but the Western Lagoon causeway remains a solid structure preventing interconnectivity. This increases the value of the Mexico Lagoon/Jones Lagoon and wetland system in helping mediate flood effects to downstream residents.

Wetland patches, with large to small lagoons and ponds to no water bodies, are scattered throughout the PGH project area, becoming filled with water as wet season rains raise the water table, with high water usually peaking in December. The actual extent of groundwater reservoirs and seasonal rainfall effects in this area is very poorly known, but sub-surface connections among wetland areas are suspected in this flat, porous landscape. Some of those in the southern part of the project site have been "urbanized" and their flood mediation value greatly reduced. All of the wetlands have been disconnected by the present highway structure. Maintaining hydrological interconnectivity is vital to maintaining both the ecological health of these wetlands and their role in flood mediation. The proposed highway improvement project provides an opportunity to re-establish interconnectivity within this landscape, helping reduce flood impacts to local communities and a major transportation route.

4.9.5 Aquatic Macro invertebrate Fauna

Major streams and lagoons within the PGH project area were accessed by foot and by canoe to rapidly assess macro invertebrate assemblages in order to gain a greater insight into the ecology of these systems. Samples of habitat areas were collected by hand and by a long-handled D-frame having 500 micron mesh. Samples of habitats (sediment, detritus, rocks) were washed down in a bucket (rock surfaces being scrubbed with a brush) and sieved through the net, or samples collected by the net washed down in the stream. Remaining material from each sample was retained, placed in a labelled container, and preserved with 91% isopropyl alcohol. These samples were later washed down in the lab and the material picked through beneath a 20X to 40X stereomicroscope. All extracted macro invertebrates were counted and placed in labelled 4 dram vials for long term storage.

A total of 9 samples were collected and processed, including 4 from Black Creek, and 5 from Mexico Creek, representing 5 different habitats. Out of these samples, 2,823 macro invertebrates, representing 39 distinct taxa (10 higher taxa, 19 to family, 3 to subfamily, 2 invasive snail species, and 3 unidentified snail species) were collected and identified. Results of this sample effort are given in Table 4.15.

Table 4.15: Aquatic Macro invertebrate Collection Data for Jones Lagoon and Principal Stream Reaches within the PGH Project Area.

TAXA Phylum Class or Order Family-Genus	Black Cr. Rock scrub/sieve	Black Cr. Undercut bank	Black Cr. Detritus/Aq Fern mat	Black Cr. Shoreline sediment	Mex. Cr. Undercut bank	Mex. Cr. Sediment	Mex. Cr. Aq. plant patch ups	Mex Cr. Rock rapid ups mouth	Mex. Cr. Rock rapid at mouth	TOTAL
Nematoda			1							1
Turbellaria			2							2
Oligochaeta	3	6	5	9						23
Hirudinea	17			1						18
Mollusca										
Ampullariidae										P
Ancylidae	2	2		3						7
Thiaridae										
Melanoides tubercula.	4			2	6	3	3			18
M. granifera						1309		320		1,629
Unidentified-knobbed				55	37	5				97
Unidentified-ridged				160						160
Unidentified-plain				4	5					9
Sphaeriidae	3	1		11		1		2		18
Mytilidae?								33		33
Arthropoda										
Acariformes			7					1		8
Cladocera	3	4	45		36		3			91
Copepoda				2						2
Ostracoda	1									1
Isopoda					58	3	4	45		110
Amphipoda			3		81		2		2	88
Decapoda										
Palaemonidae							1			1
Insecta										
Baetidae				2	9		4	4		19
Caenidae- *Caenis*	18			6	16		3	2		45
Coenagrionidae	2		12		4		3			21
Anisoptera-small					2					2
Libellulidae					1					1
Gomphidae- *Aphylla*	1									1
Naucoridae			1							1
Elmidae Lar.	7	3		8						18
Dytiscidae Ad.		1	1		1					3
Hydrophilidae La			2							2
Sciridae			6							6
Coleptora Unid. Adu.			5							5

Pyralidae-Gills								**2**		**2**
Hydroptilidae				**2**						**2**
***Orthotrichia*-like**	**2**							**21**		**23**
Tapered sand case					**16**			**13**		**29**
Leptoceridae	**4**				**1**					**5**
Limnephilidae							**1**			**1**
Hydropsychidae							**2**	**6**		**8**
Ceratopogonidae lar.			**4**							**4**
Ceratopogonidae pup.			**2**							**2**
Chironomidae pupa			**3**						**2**	**5**
Chironominae	**11**	**2**	**22**	**3**	**2**		**76**		**24**	**140**
Tanypodinae		**1**	**15**	**2**	**3**		**4**	**5**	**1**	**31**
Rheotanytarsus							**1**			**1**
Culicidae										
Culex			**2**				**2**			**4**
TOTALS	**78**	**20**	**138**	**268**	**278**	**1309**	**109**	**454**	**29**	**2,683**

One revealing outcome of the macro invertebrate survey is the population densities obtained by the invasive Asian snail, the Quilted Melania (*Tarebia granifera*), and secondarily by the Asian Thorn (*Melanoides tuberculata*), both being small snails introduced through the aquarium industry. In one sample site along Mexico Creek, a shallow sediment sample covering less than a ¼ of a meter in area, yielded 1,300+ *T. granifera*, and very little else, not even *oligochaetes*. Most sites sampled contained either one or both of these invasive species. The full impact of these snails on native snails and other aquatic fauna is not known. Two of the three small, unidentified snails collected from sediments just below the shoreline in Black Creek represented the bulk of that sample, and were observed in other areas of the stream. They are probably at least locally important, but further efforts to find any appropriate identification keys are required for these and other snails in these blackwater streams.

Undercut bank samples from Mexico Creek yielded high numbers of isopods and amphipods, both groups predominately being detritus feeders, shredding leaves and stems. This habitat also yielded relatively high numbers of Cladocera and the small, unidentified snail with the knobbed shell.

Dominant mayflies found in the area were primarily *Caenis* (Caenidae) and secondarily mayflies of the family Baetidae. Non-biting midges in the subfamily Chironominae were found in most samples, sometimes reaching high numbers, and are probably feeding on detritus and possibly some living plant material. Midges in the largely predaceous subfamily Tanypodinae were also common, but less abundant than Chironominae.

4.9.6 Study Area Flora Survey

4.9.6.1 Introduction

Large sections of Belize's major highways traverse lowland savannah ecosystems. Savannahs in Belize vary from open grassland to savannah woodland and both structure and composition may vary with small changes in local conditions that are inherent in the soil properties. Savannahs tend to predominate where forests cannot be maintained and are found over nutrient poor soils.

Savannahs are grassland ecosystems with few trees. The ground cover in these ecosystems are typically dominated by bunch wiry grasses and sedges, with open vegetation such as shrubs, trees and palms, that may occasionally occur in clusters of pure pine stands separated from large clumps of palmetto but do not form a continuous canopy. They are associated with low nutrient soils and are often water-logged during the "wet" season and may dry during the "dry" season, so that much of the vegetation is hardy and able to withstand drought and submersed conditions. The vegetation in savannahs has been further modified by seasonal fires which frequently sweep the savannah. Tree species such as the Caribbean pine (*Pinus caribea*), calabash (*Cresentia cujete*), oak (*Quercus* spp.), craboo (*Byrsonima crassifolia*), madre de cacao (*Gliricidia sepium)* and the palmetto (Acoelorraphe *wrightii*) are relatively fire resistant. The combination of wet-season flooding, dry-season drought and fire provides stability to savannahs giving them their characteristic open vegetation landscape.

Savannah ecosystems occupy almost 10% of Belize's land area. It is estimated, however, that approximately 12% of the once existing lowland savannah has already been lost to development. Gap analysis in 2005 revealed that, compared to other ecosystems, savannahs are under-represented in the National Protected Areas System. This now needs to be urgently addressed because savannahs are experiencing an increasing variety and severity of threats. Since it occurs on relatively level ground in close proximity to the coast and is easily accessible, there is pressure to clear savannahs for settlement and for infrastructure.

Savannah areas are often preferred sites for infrastructure. As an example, the two largest airstrips in Belize namely Philip SW Goldson International Airport and the Placencia airstrip were both constructed on savannah tracts. The new capital city Belmopan was built in a savannah landscape and later new settlements such as San Felipe, Shipyard, Mahogany Heights and others have also been sited on savannah land. In addition, sections of the Philip Goldson Highway, George Price Highway, Hummingbird Highway, and the Southern Highway were aligned and constructed through Savannahs. Recently, other municipal facilities including Belize's national solid waste dump was located on savannah, although some have pointed out the possible negative effects on groundwater unless mitigation is in place.

Despite poor potential for farming, savannahs are being converted for large and small scale agriculture, altering the drainage, nutrient cycling and fire regimes and resulting in habitat degradation. Although, many savannah areas have been considered in the past as generally not suitable for most forms of agriculture, large areas have been converted to pasture and for aquaculture, mainly for shrimp farming.

Some of these areas are particularly concentrated in certain parts of the country, with for example, most of the conversion of savannah to pasture taking place in the northern and western districts of Orange Walk and Cayo, while most shrimp farms have been constructed on southern savannahs in Stann Creek and Toledo. In the southern districts limited savannah areas have also been converted and used for the growing of bananas, citrus and rice. Attempts to convert savannah to smallholder Tilapia farming has occurred in the Belize District.

The poorly drained and infertile soils of many savannah areas have been mostly evaluated as suitable for pine, pasture, or aquaculture. Some of the better drained areas have been classified as suitable for housing and infrastructure such as roads.

4.9.6.2 Importance of Savannahs

The importance of lowland savannahs as distinctive landscapes of ecological and potentially significant economic value needs to be recognized. For example, Palmetto palms (*Acoelorraphe wrightii)* grow in savannahs and their seeds have medicinal properties used in the treatment of prostate cancer. According to the Forest Department there is demand for the palmetto palm seed which is exported to Canada. The collection of palmetto palm seeds provides an income to communities throughout northern Belize and in the southern coastal plains where this commodity is harvested. Some communities have voluntarily moved towards conserving these savannahs due to the income earned from the collection of palmetto palm seeds. Savannahs, in addition, provide for the harvest of pine, palms, and other plant resources and have potential for ecotourism development.

Plant biodiversity in savannahs were thought to be species poor, yet Goodwin et al. (2012) found more than 950 plant species in lowland savannahs. This is approximately 28% of the nation's flora as recognised by Balick et al. (2000) and 380 of these are savannah specialists. Of the 41 vascular plant species reported by Balick et al. (2000) as endemic to Belize 18 (44%) are recorded in the lowland savannahs. While some savannah plants are widespread, others, including some endemics, show localized distributions. With 75% of savannah areas not under protection, this means that many of the endemic, endangered, or threatened species are vulnerable to having more of their habitat lost, as areas of savannah are converted to other uses.

Some savannah areas, such as those where endemic plant species occur, are of high conservation value and require protection. One approach that is now widely used to establish the value of conserving or protecting an ecosystem, especially where some of the value is not easily expressed in monetary terms, is to assess the services that an ecosystem provides. This is often expressed by outlining and where possible also quantifying the provisioning, supporting, regulating services provided by the ecosystem. This approach can be applied to savannah areas, so that their appropriate and sustainable use is made and the biodiversity of these areas are not degraded.

Associated with Belize's lowland savannahs are marshes, swamps, wetlands, and streams. Marshes, sometimes referred to as "swamps", are areas of vegetation that are susceptible to flooding. Marshes are fed by groundwater or surface water. The difference between a marsh and a "swamp" is the vegetation type that they sustain. Marshes are dominated by soft stem vegetation such as Eleocharis (spikerushes), rushes, grass-mats, cattails, bulrushes, water-lilies and sedges from the family Cypraceae; while "swamps" are dominated by woody plants such as logwood (*Hymaetoxylum campechanum*), amate (*Ficus sp*.), bullet tree (*Bucida buceras*), mangroves and other trees and shrubs that can tolerate rich, organic soils covered in standing water.

Marshes are classified as wetlands frequently or continually inundated with water, characterized by emergent soft-stemmed vegetation adapted to saturated soil conditions. Marshes recharge groundwater supplies and moderate stream flow by providing water to streams. This is an especially important function during periods of drought. The presence of marshes in a watershed helps to reduce damage caused by floods by slowing and storing flood water. As water moves slowly through a marsh, sediment and other pollutants settle to the substrate or floor of the marsh. Marsh vegetation and microorganisms also use excess nutrients from fertilizers such as nitrogen and phosphorous for growth that can otherwise pollute surface water.

Due to their high levels of nutrients, freshwater marshes are highly productive ecosystems. They sustain vast array of plant communities that in turn support a wide variety of wildlife within this vital wetland ecosystem. As a result marshes sustain a diversity of life due to high habitat value. Many of the most frequently inundated marshland and savannahs have relatively high conservation value in terms of the habitats they create for birds and mammals. Though not rich in species diversity, the savannahs support a variety of birds, mammals, and reptiles.

Activities Impacting Wetlands

The marshes in Belize, like other ecosystems, have sustained major losses to development. Some marshes have been degraded by excessive deposits of nutrients and sediment from mining, construction and farming. Severe flooding and nutrient deposition to downstream waters have often followed destruction and degradation. Such environmental problems demonstrate the vital roles these wetlands play.

Where lowland savannahs give rise to slight differences in gradients this results in the formation of streams that drain the savannah wetlands. Along these streams gallery forests are formed as corridors which project into the savannah landscape where otherwise trees grow sparsely. In addition to grasses and sedges, gallery forests support a mix of vegetation and tree species such as gombolimbo (*Busera simaruba*), bullet tree (*Bucida buceras*), cotton tree (*Ceiba pentandra*), yemeri (*Vochysia hondurensis*), bri-bri (*Inga sp*.) and others. Figure 4.48 provides a generalized view of the vegetation of northern Belize with project site highlighted. These gallery forests are able to exist where the surrounding landscape does not support forests due to various reasons. The riparian zones in which they grow offer greater protection from fire which would kill tree seedlings. In addition, the alluvial soils of the gallery habitat are often of higher fertility and better drainage than the soils of the surrounding landscape and have a more reliable water supply at depth.

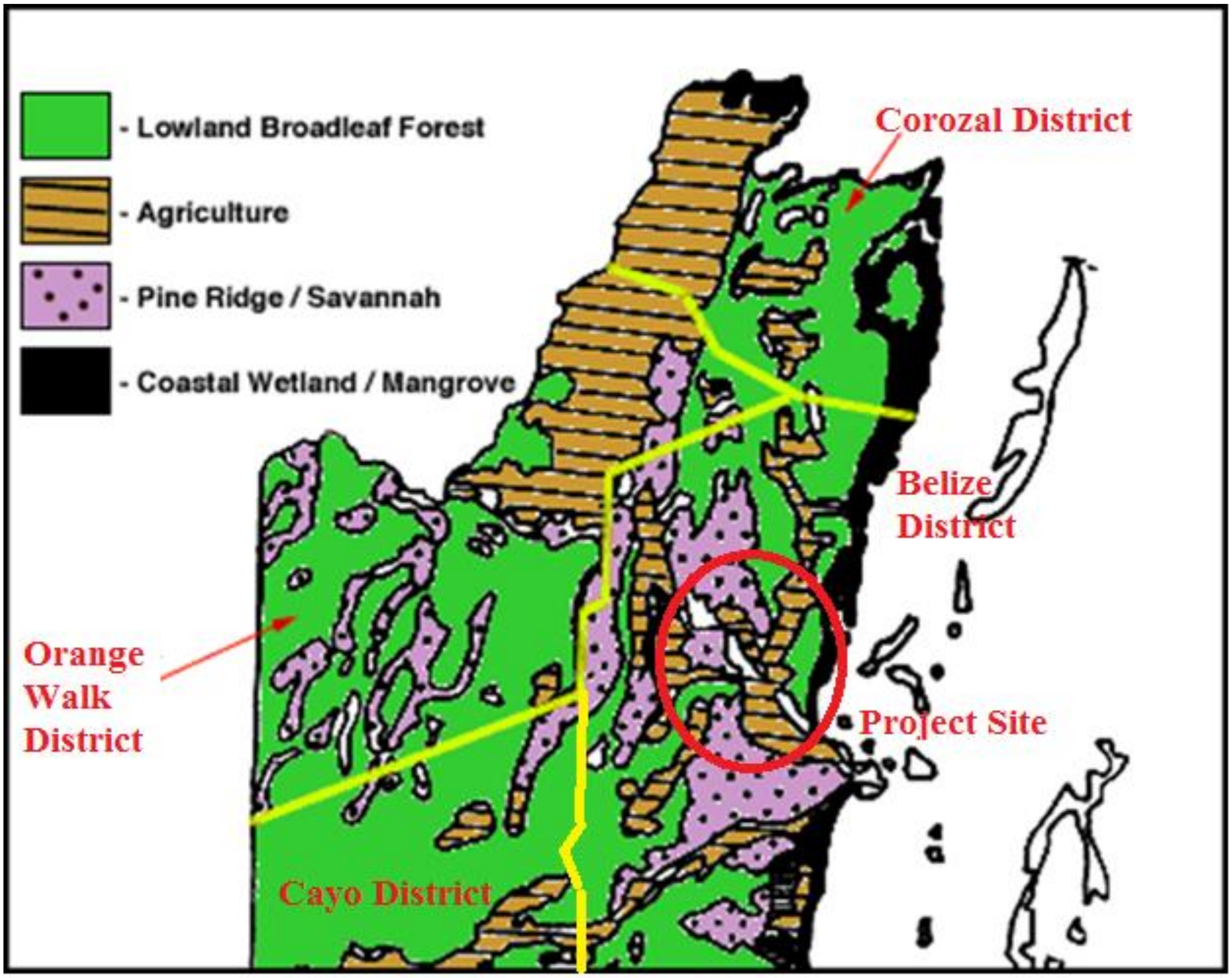


Figure 4.48: G**eneralized view of the vegetation of northern Belize with project site highlighted.**

As a result, the boundary between gallery forests and the surrounding grassland is usually abrupt, with the ecotone being only a few meters wide. Gallery forests are faced with similar threats to savannahs and consideration for their conservation should be given.

4.9.6.3 Description of the Flora in the Study Site

A vegetation description is made of the study area on the Philip SW Goldson Highway from Mile 8.5 to Mile 24.5. The study was designed to capture any existing vegetation up to one kilometre on each side of the highway within the study area. The main challenge encountered in the study area was that of severe disturbances due to infrastructure development, mining, and wildfires.

Noting that the study area is comprised of a lowland savannah ecosystem; in this study we define lowland savannah as any natural or semi-natural, fire influenced ecosystem with a continuous herbaceous layer dominated by native grasses and sedges with trees and shrubs that may occur to a greater or lesser extent. Where trees and shrubs are present the structural composition is predominantly pine (*Pinus caribaea*), palmetto (*Acoelorraphe wrightii*), craboo (*Byrsonima crassifolia*), sandpaper tree (*Curatella americana*), calabash (*Cujetu jabatus*), *Melastomataceae* spp. and oak (*Quercus oleoides*).

Several vegetation formations within lowland savannah are cited by different authors historically and other more recent researchers have used their own classification system to describe finer scale vegetation types at different sites within the lowland savannah. For example, Bridgewater *et al*. (2002) discussed the structure of the savannahs and wetlands and identified six distinct vegetation types within the savannah landscape and five vegetation types within the associated wetland ecosystem. Savannah classes included *grassland & scrub grassland*, *pine palmetto savannah*, *palmetto thicket*, *savannah orchard*, *woodland and pine ridge* and *oak thicket*. The wetland was observed to consist of *fringing riverine red mangrove*, *cutting grass marsh*, *marl flat*, *sedge marshland* and *Eleocharis calabash marsh*.

Early work on the floristic composition of the Belizean savannahs, such as Johnson *et al.* (1973) and Johnson & Chaffey (1974) traditionally focused on pine timber and its extraction, and for many years only brief discussions of the vegetation and characteristic species were available for the savannahs of Mountain Pine Ridge (Hunt, 1970; Johnson *et al.*, 1973) and the southern coastal plain (Hunt, 1970; Johnson & Chaffey, 1974).

There is a well acknowledged need for longer term studies on the ecological determinants of savannahs globally in addition to those relating to fire (Furley, 2004). However the pre-requirement for such studies is baseline data and comprehensive vascular plant species lists. Belize has a preliminary checklist of vascular plant species (Balick *et al.*, 2000) which provides great detail on the habit, local uses, and vernacular names of 3,408 species, but does not indicate which habitat a species is associated with. Local checklists such as those by Bridgewater *et al.* (2006; 2002) and by Hicks *et al.* (2011) give some indication of habitat and distribution of species. These latter papers have highlighted the need for a nationwide checklist for the lowland savannah flora which would enable the creation of identification keys, photographic guides and potentially highlight plant species of special worth and areas for conservation. The aim of this study is to provide a checklist of savannah species within the study area.

In this study four savannah variants were identified to include open savannah, palmetto savannah, pine savannah, and thicket savannah. The open savannah variant consists of grasses and sedges with very few, if any, scattered trees and shrubs. The palmetto savannah variant is dominated *by* clusters of *Acoelorraphe wrightii* with open areas of grasses and sedges. The pine savannah variant is dominated by pine stands that do not form a continuous canopy and the ground floor is dominated by grasses, sedges, and shrubs such as the sandpaper tree, Melastomataceae spp., scattered oaks, and craboo. The thicket savannah variant is indicative of changes in the soil composition and nutrient richness and the vegetation is made up of tree species that include yemeri (*Vochysia hondurensis*), pine, oaks, nargusta (*Terminalia amazon*), mayflower (*Cordia dodecandra*), bullet tree and other tree species with no single tree species being dominant. The thicket floor is mostly covered by cutting grasses, sedges, and shrubs.

4.9.6.4 Field Methodology

A species checklist was compiled (Annex IX) using the most recent lowland savannah plant checklist by Goodwin et al. (2012). The checklist was for field use to compare plant species identified. Those plants that were not readily identified were taken to the Belize National Herbarium for keying and comparison with voucher specimens.

A stratified random sampling of the distinct savannah formations as mapped by Cameron *et al*. (2010) within the study area was made. With the use of a scientific calculator random numbers were generated and used to plot the coordinates of the sample sites. In addition, Cameron's map showing the distinct savannah formations was compared to recent satellite imagery. The coordinates that fell on disturbed sites with infrastructure and outside of the distinct savannah formations were not used.

Twelve 10m x 50m plots were measured to collect field data. A Garmin GPS was used to identify the plot coordinates in the field. Plots were aligned west-east with plot coordinates used as the western or eastern boundaries of the plot. Plot coordinates on the eastern side of the study area, with the highway being considered as the "centre" of the study area, was used to demarcate the western boundary transect. For, those plots located on the western section of the study area, their coordinates were used as the eastern transect boundaries. In addition, a yellow nylon ¼" 50m rope was used to demarcate the centre of all transects. Researchers also used five metre measuring tapes to guide themselves on the northern and southern transect boundaries. Since the objective of this exercise was to develop a checklist of the plant species that occur in the study area, those plants that fell immediately outside the plots not previously recorded during this sampling exercise were also recorded.

4.9.6.5 Results

Of the 41 species, endemic to Belize (Balick *et al.*, 2000), 18 are known to occur in the lowland savannah (Table 4.16).

Table 4.16: Endemic species found in the lowland savannahs of Belize.

Family	Species
Apocynaceae	***Metastelma stenomeres* (Standl & Steyerm) W.D. Stevens**
Arecaceae	***Schippia concolor* Burret**
Asteraceae	***Ageratum radicans* B.L. Rob.**
Celastraceae	***Crossopetalum gentlei* (Lundell) Lundell**
Celastraceae	***Zinowiewia pallida* Lundell**
Eriocaulaceae	***Paepalanthus belizensis* Moldenke**
Eriocaulaceae	***Paepalanthus gentlei* Moldenke**
Eriocaulaceae	***Syngonanthus bartlettii* Moldenke**
Eriocaulaceae	***Syngonanthus hondurensis* Moldenke**
Eriocaulaceae	***Syngonanthus lundellianus* Moldenke**
Eriocaulaceae	***Syngonanthus oneillii* Moldenke**

Euphorbiaceae	***Dalechampia schippii* Standl.**
Hypericaceae	***Hypericum aphyllum* Lundell**
Myrtaceae	***Calyptranthes cuneifolia* Lundell**
Passifloraceae	***Passiflora urbaniana* Killip**
Poaceae	***Axonopus ciliatifolius* Swallen**
Poaceae	***Paspalum peckii* F.T. Hubb.**
Zamiaceae	***Zamia prasina* W. Bull**

Several savannah endemic plants were identified within the PGH project area investigated by Goodwin, et al. (2013). These include *Passiflora urbaniana*, a vine locally called Grampa Balls; *Ageratum radicanus*, a lavender-blossomed composite; *Syngonanthus hondurensis*, a small pipewort, and *Crossoptalum gentlei*, a small, red-berried savannah tree.

Figure 4.49: Savannah endemic plants (LtoR) Passiflora urbaniana; Ageratum radicanus; Syngonanthus hondurensis and Crossoptalum gentlei. **Source Goodwin, et al. Darwin.**

In addition, *Pinus caribaea* (least concern) and *Schippia concolor* (vulnerable) were the two species recorded in the study area that are listed in the current IUCN Red List of Threatened Species for Belize (IUCN, 2010) (Table 4.17). The most species-rich genus is *Rhynchospora* (20, *Cyperaceae*) which is followed by the other important genera *Scleria* (10, *Poaceae*).

Table 4.17: Belize Savannah Species listed in IUCN 2010 Red Data List of Threatened Species.

Family	Species	IUCN
Apocynaceae	*Aspidosperma megalocarpon* Müll. Arg.	NT
Arecaceae	*Schippia concolor* Burret	UV
Combretaceae	*Conocarpus erectus* L.	LC
Cyperaceae	*Bulbostylis hispidula* (Vahl) R.W. Haines	LC
Fagaceae	*Quercus purulhana* Trel.	VU
Lamiaceae	*Vitex gaumeri* Greenm.	EN
Pinaceae	*Pinus caribaea* Morelet	LC
Rhizophoraceae	*Rhizophora mangle* L.	LC
Zamiaceae	*Zamia prasina* W. Bull	CR
CR = critically endangered; EN = endangered; NT = lower risk/near threatened; VU = vulnerable; LC = least concern.		

During this study 150 species representing 57 families were recorded. This is an estimated 15% of the known plant species that occur in Belize's lowland savannah ecosystems.

4.9.7 Study Area Fauna Survey

4.9.7.1 Introduction

Savannahs were once thought to be barriers for many large mammals such as jaguars. Although jaguars show preference for habitats with greater tree cover, valleys, ridgelines, and lower human modification; new research, however, has revealed that at least some species will use a pine savannah matrix when moving between forests. These habitats form important corridors that allow an exchange of individuals between populations, which may help prevent the negative effects of inbreeding and reduced genetic diversity that often occur within isolated populations. Corridors may also help facilitate the reestablishment of populations that have been reduced, displaced, or eliminated due to random events such as hurricanes, fires and diseases.

Corridors have been described as being associated with water or land. Water corridors are called riparian forests and usually come in the form of rivers and streams. Land corridors come on a scale as large as wooded strips connecting larger woodland areas. Land corridors can be as simple as a line of shrubs along a live tree fence. Such areas can facilitate the movement of small animals, especially birds, from tree to tree, until they find a safe habitat to nest in.

These corridors can also be aesthetically pleasing, which can sometimes encourage communities to accept and support them. Thus, recognizing that developments such as roads, settlements and farms can interrupt plants and animals in the region being destroyed; habitats corridor could be considered as a possible solution in an area where destruction of a natural area has greatly affected its native species.

Even in paradise there is trouble. As wildlife habitats are destroyed and fragmented due to human encroachment the incidences of human-wildlife conflicts increase. Jaguar human conflicts are on the rise in the area. Jaguars predating on livestock including dogs and other domesticated animals are frequently reported to occur in the area. Free range cattle rearing is the common practice in the area. This animal husbandry lends itself to jaguar human conflicts. The Forest Department, through its Jaguar Program, in collaboration with PANTHERA, is working with ranchers in the area in an attempt to adopt best animal husbandry practices in other to reduce the predation of cattle on jaguars.

Another trouble in paradise is that of crocodile human conflicts. Most recently, in the village of May Pen, a young girl was attacked and killed by a crocodile along the banks of the Belize River. The crocodile was trapped and removed from the area by the Forest Department. The area appears to have very healthy and stable crocodile populations. In Black Creek, for example, during this wildlife survey, 28 crocodiles were spotted during a two-hour night count.

The Wildlife Protection Act has been effectively used to conserve wildlife in Belize. However, the conservation of species such as the crocodile has reached a level in which a determination needs to be made and perhaps through the use of properly introduced policies and legislation would embrace ranching operations that would derive a benefit from the conservation of the species. Any decisions taken regarding the crocodile needs to follow proper guidelines set by the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES).

4.9.7.2 Birds

The importance of the bird diversity in the project area is reflected by the presence of two Important Bird Areas. The Crooked Tree area, with its large congregations of waterfowl, falls under BZ2003, and the coastal areas fall into BZ2004 (Figure 4.50). Both are susceptible to aquatic pollution impacts from the road, which may alter the trophic structure.

The area also falls within Belize's National Key Biodiversity Area Level 2 (KBA 2) (Figure 4.51), based on the diversity of globally threatened species and species of national concern (Meerman, 2007).

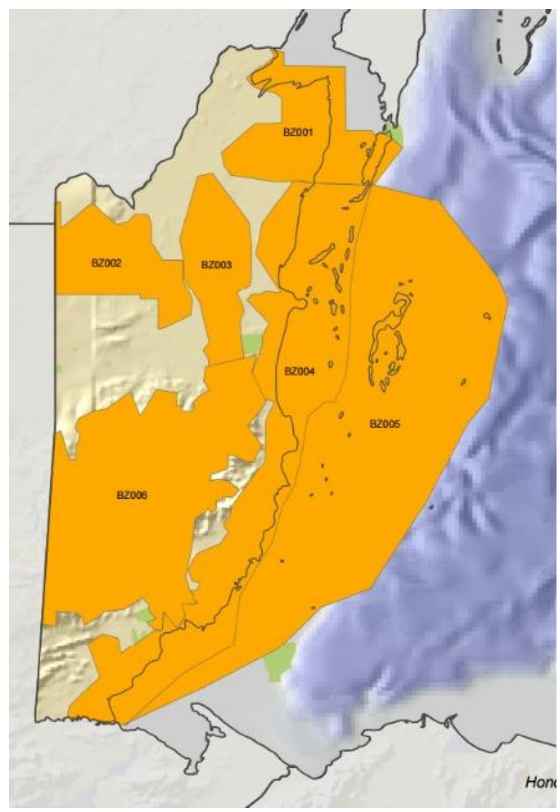


Figure 4.50: Important Bird Areas (IBAs) of Belize (Miller et al.,, 2007).

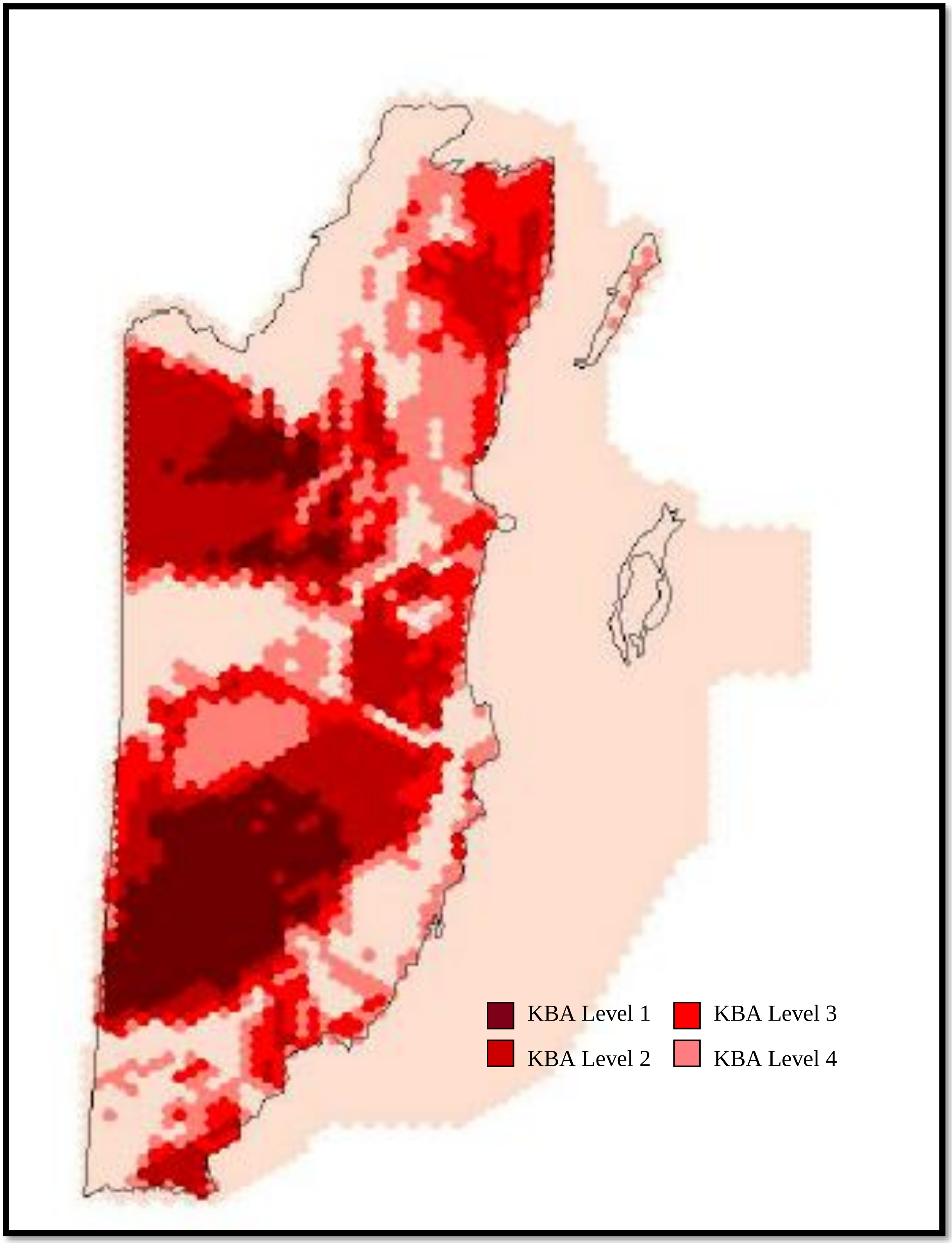


Figure 4.51: Key Biodiversity Area outputs based on: IUCN species and species of national concern (Marxan outputs, Meerman, 2007).

With its rich mosaic of 19 natural ecosystems and the presence of key wetland areas such as Crooked Tree Wildlife Sanctuary, bird diversity is high, with three hundred and seventy (370) species recorded within the project scope to date (BAS, 2004, eBird, 2017, Miller et al., 2006). The majority of species are indicative of wetland and lowland pine savannah habitats, with limited representation of broadleaf forest species except in riparian areas, thickets, and gallery forests. The area hosts a diverse population of migratory warblers, ducks, and other species during the migration season and is an important dispersal area for young herons, egrets, ibis and storks. The Crooked Tree and May Pen lagoons, in particular, were ranked as 'extremely important' for water birds (Miller et al., 2006). These lagoons shrink during the dry season, providing an important foraging area for many species that gravitate to these lagoons as ephemeral wetlands disappear. The lagoons are also important for ducks, jabiru, wood storks, and waders. Several species are indicative of the pine savannah, including the yellow headed parrot and savannah sparrow. There are also species considered as human commensals, such as great tailed grackles, found in highest densities in the rural communities along the road.

Bird Species of Concern

Three species of international concern (Table 4.18) are highlighted for the project area (Endangered or Vulnerable) – the yellow-headed parrot, agami heron and great curassow. A further 10 are considered Near Threatened and 352 of Least Concern.

Ten species of highest national and regional priority are also identified (Partners in Flight, draft, 2017), including Yucatan endemics such as the Yucatan vireo and black catbird (Table 4.28). Also of concern are colony nesting water birds – many of these use coastal mangrove cayes and are therefore very vulnerable to anthropogenic disturbance, whether from unregulated tourism impacts of caye development.

Table 4.18: Priority Species in the Study Area.

Global Priority			**National Priority**	
Endangered			Yellow-headed Parrot	*Amazona oratrix*
Yellow-headed Parrot	*Amazona oratrix*		Reddish Egret	*Egretta rufescens*
Vulnerable			Yucatan Vireo	*Vireo magister*
Agami Heron	*Agami agami*		Black Catbird	*Melanoptila glabrirostris*
Great Curassow	*Crax rubra*		White-crowned Pigeon	*Patagioenas leucocephala*
Near Threatened			Yucatan Woodpecker	*Melanerpes pygmaeus*

Reddish Egret	*Egretta rufescens*		Yellow-lored (Yucatan) Parrot	*Amazona xanthlora*
Semipalmated Sandpiper	*Calidris pusilla*		Rose-throated Tanager	*Piranga roseogularis*
White-crowned Pigeon	*Columba leucocephala*		Yucatan Poorwill	*Nyctiphrynus yucatanicus*
Northern Mealy Parrot	*Amazona guatemalae*		Yucatan Flycatcher	*Myiarchus yucatanensis*
Olive-sided Flycatcher	*Contopus cooperi*			
Wood Thrush	*Hylocichla mustelina*			
Black Catbird	*Melanoptila glabrirostris*			
Golden-winged Warbler	*Vermivora chrysoptera*			
Painted Bunting	*Passerina ciris*			
Reddish Egret	*Egretta rufescens*			

The yellow headed parrot (*Amazona oratrix belizensis*) is globally endangered following a rapid population decline across the region, primarily as a result of habitat loss and degradation and the illegal pet trade (IUCN, 2017). In the 1960's, the population was thought to number 70,000, but declined to an estimated 7,000 in 1978. The current population size is thought to be around 1,200 birds (Larder, pers. com.). 75% of the global population is thought to exist in Belize, which is considered very important to the maintenance of regional population (Partners in Flight, draft, 2017).

This species has very restricted habitat requirements, requiring old oak or pine growth for nesting holes and successful nesting. Rapid expansion of agriculture and urban areas in the savannah habitat, combined with increasing anthropogenic fires, in addition to the legal harvest of pine stumps and snags has had a serious impact on the wild populations. Tropical riparian forest provides foraging habitat for the adults, which move daily between nesting / roost sites, and fruiting trees. In the project area, remaining tropical forest is disappearing, impacting the food resources available for these parrots. Whilst it is thought unlikely that the population will be lost in the next 20 years, significant intervention is needed to ensure the population in maintained at a viable level – this includes effective fire management, improved protection of nesting trees, enforcement against nest poaching and removal of critical nesting trees by illegal logging, and maintenance of riparian and broadleaved forest vegetation. The Forest Department has successfully instituted a parrot pet trade registration in an effort to control and halt the taking of parrots as pets.

The agami heron (*Agami agami*) is considered globally Vulnerable (IUCN, 2017), and is generally rare throughout its range (including Belize). Modelling suggests that it may lose 18.6-25.6% of suitable habitat within its distribution over three generations (22 years) based on a model of Amazonian deforestation (Soares-Filho et al. 2006, Bird et al. 2011). It occurs in lowland swampy stream and lake margins within tropical forest, where riparian vegetation is undisturbed…these quiet, riparian forests and streams are under-represented within the National Protected Areas System, and clearance is a major impact on habitat requirements for this species. This species relies on the water quality and intact trophic structure of the forest streams, with a diet that focuses almost exclusively on fish.

The reddish egret (*Egretta rufescens*), categorized as Near Threatened (IUCN, 2017), has a large range, within which it generally occupies only a narrow belt of coastal habitat. The global population is estimated to be 5,000 – 7,000 individuals, with 3,500 to 4,250 breeding pairs (Wilson et al., 2012). This species is distributed throughout the coastal areas in USA and Mexico, and breeds in Belize, though in small numbers. Nesting habitat in the Yucatan region and further south into Belize appears to be largely in mangroves and on mangrove cayes. Birds travel to their foraging area, which include the wetlands of the project area. Direct threats include development of caye nesting sites and of wetland foraging habitats.

Some species such as the Yucatan flycatcher (*Myiarchus yucatanensis*) and Yucatan vireo (*Vireo magister*) are endemic to the region, with very restricted global ranges. The Yucatan flycatcher is restricted to lowland forests and forest edges in Mexico, Belize, and Guatemala, and does well in degraded forest habitats. The Yucatan vireo has an even more restricted range, being found only in south-east Mexico and Belize. The project area is the southernmost part of the range for both species, which are both considered of national and regional concern. Both are thought to have stable populations, rating as of Least Concern globally (IUCN, 2017).

The Yucatan peninsula is the most northerly extent of the jabiru (*Jabiru mycteria*), one of two large stork species found in the lowland wetlands of the project area. They build solitary nests in large trees – the availability of suitable nesting sites may be one of the key limiting factors to maintenance of the population, though there are also issues of nest disturbance if nest sites become too accessible, as these birds are considered to have high touristic value. The second large stork species, the wood stork (*Mycteria americana*) also relies on the wetlands of the area, and congregates in large numbers at Crooked Tree Wildlife Sanctuary during the dry season, when aquatic food resources are concentrated in the lower water levels. Unlike the jabiru, wood storks are colony nesters, using mangrove cayes primarily in north east Belize, and moving to the project area to forage once the young are fledged.

Figure 4.52 shows eBird (www.ebird.org) species distribution maps. NOTE: These maps provide an indication of presence and distribution, but only records from expert ornithologists have been used in developing the species list.

The Snail Kite (*Rostrhamus sociabilis*) is indicative of healthy wetland systems, as it is reliant on a specialized diet of water snails – predominantly the apple snail. This species is seen along the roadsides and in Crooked Tree, though numbers are declining.

The great curassow (*Crax rubra*; IUCN status: Vulnerable) is a large game species that faces heavy hunting pressure across Belize and in the Central America region generally. The great curassow is declining in Belize, one of the few countries in the region that still permits hunting of this species, but is maintained in those protected areas that have effective management (Jones et al, 2001). It is however heavily hunted outside of protected areas throughout Central America, with significant population decline (Birdlife International, 2017). This species is more often associated with areas of broadleaf forest.

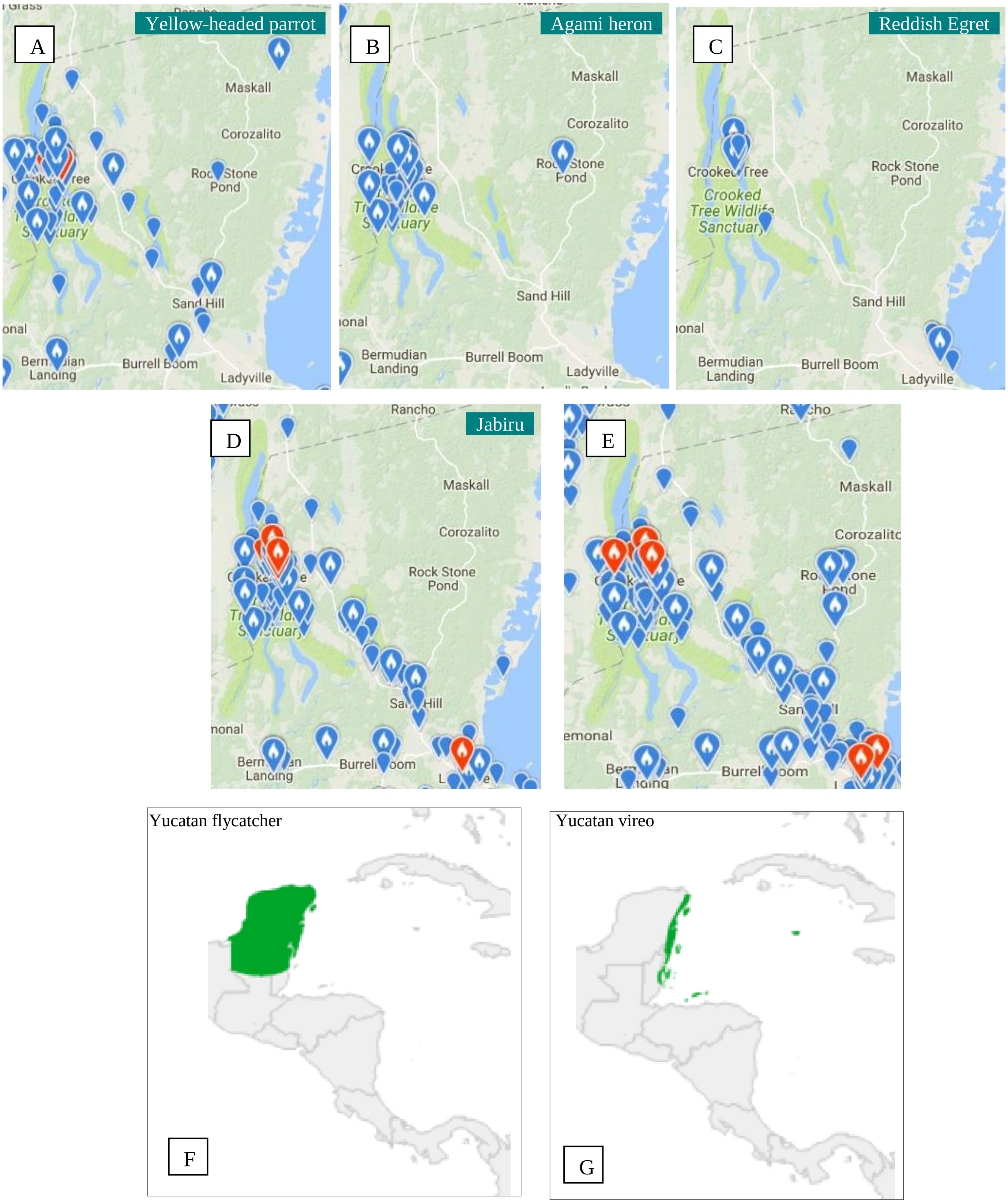


Figure 4.52: Distribution of Bird Species: A: Yellow Head Parrot, B: Agami Heron, C: Reddish Egret, D: Jabiru, E: Wood Stork, F: Yucatan flycatcher and G: Yucatan vireo.

4.9.7.3 Amphibians and Reptiles

Based on habitat availability, known distributions, and confirmed species records, a total of 95 species of amphibian (17 species) and reptile (78 species) can be expected to occur over the landscape through which the section of the Philip Goldson Highway to be upgraded passes. This represents an impressive 58% of all the 165 species recorded in Belize, a diversity that reflects the diversity of broadleaf, savannah, wetland, riparian, gallery forests, thickets, and coastal ecosystems occurring within the 4km buffer area that is the subject of the assessment.

In terms of conservation importance of the area, by far the highest value is of the wetlands and Belize River tributaries in affording habitat to the critically endangered hicatee (*Dermatemys mawii*) – a species that was locally abundant in the area up to the mid 1980's, when the national decline of the species gathered pace – following that in the remainder of the species' range in Mexico and Guatemala. Whilst afforded a degree of protection in Belize through a closed season and bag limits, these laws are still broadly flouted and the species decline continues. The dark, deep waters of portions of Black Creek and Mussel Creek provide some refuge for remaining individuals, with free-diving hunters being rather more constrained in the thoroughness of their searches in such conditions. Fishing nets however remain an ongoing threat even in these locations.

Other freshwater turtles that are near-threatened are, *Claudius angustatus, Kinosternon acutum, Kinosternon scorpiodes*, *Rhinoclemmys areolata* and *Staurotypus triporcatus* – whose populations are considered as being relatively healthy within the project area, with little anthropogenic pressure on them. The vulnerable *Crocodylus acutus* is known to occur along the coastline off Ladyville, but breeding sites there have not been reported. *Crocodylus moreletii* is relatively numerous in the freshwater wetlands and creeks, and is considered by many to be a nuisance and threat to humans considering the recent human fatality attributed (Tellez, M., pers. comm.) to habituation of the crocodiles through inappropriate contact and feeding.

Most of the remainder of the herpetofaunal (amphibian and reptile) species of the area can be broadly considered to be somewhat ubiquitous lowland species that occur across much of the northern physiographic region of Belize.

4.9.7.4 Mammals of the Study Area

Twenty eight mammal species have been recorded within the project area, of which two are considered species of international concern, (IUCN Red List, 2017) and three are considered at Lower risk / Near Threatened Table 4.29.

Table 4.19: Species of International Concern of the project area (IUCN: Red list 2017).		
Endangered	Yucatan Black Howler	***Alouatta pigra***
	Baird's Tapir	***Tapirus bairdii***
Lower Risk / Near Threatened	Jaguar	***Panthera onca***
	Margay	***Leopardus wiedii***
	Neotropcal River Otter	***Lutra longicaudus***

Species such as collared peccary, Baird's tapir and white-tailed deer are highlighted as of National Concern (Meerman, 2005) as hunting pressure increases and forested habitat decreases. These species have also been identified as of continuing concern in a 2017 workshop focused on revising the National Threatened Species List. Large seed dispersers such as these are considered critical to the long term health of the forests in the area.

Riparian species closely associated with the wetlands include the Neotropical river otter and racoon both recorded from the Crooked Tree area and the Belize River (Walker et al., 2004; Walker 2017)), and the long-nosed bat and Mexican bulldog, or greater fishing bat (Boles, 2017). Paca and Yucatan black howler monkeys are known to frequent the bank sides of rivers and creek, the latter were observed along the Belize River, Black Creek and in trees on the Grace Bank access road.

The one primate species confirmed within the project area is the Yucatan black howler monkey (*Alouatta pigra*) (Endangered, IUCN 2017). This species is a Yucatan endemic, with a limited range that encompasses Belize, the Mexican Yucatan and a small portion of north-eastern Guatemala, and is generally associated with broadleaved forests and the riparian forests of creeks and rivers. Geoffroy's spider monkeys (*Ateles geoffroyii*) have been reported as present historically in the higher forest areas adjacent to Spanish Creek, west of the project area, though this species is generally associated with large tracts of undisturbed, tall tropical broadleaf forest, which is limited in the project area.

Savannah species such as white-tailed deer and nine-banded armadillo are present in the extensive pine and grassland savannah areas adjacent to the road, whilst patches of tropical broadleaf forest that include gallery forests, thickets and riparian areas, whilst small, provide some habitat for forest-dependent species such as red brocket deer and margay. However, following increasing urban expansion along the George Price and Philip Goldson Highways, the broadleaf forest extent and connectivity is rapidly decreasing, with reduced ability to support mammal species requiring large tracts of undisturbed, connected habitat, as seen by the disappearance of key species such as white-lipped peccary (G. Tillet, pers. com.).

Of the opossums, only the common opossum has been recorded in the area to date, though an overview by University of Belize students in 2002/2003 lists the water opossum (a ‘near threatened’ species, IUCN, 2004), following input from community members. This still requires verification before being included. Both the Northern tamandua and the nine-banded armadillo have been recorded as present within the protected area.

Bats are under-represented on the species list at present - three species have been recorded (the long-nosed, or proboscis bat (*Rhynchonycteris naso*), the Mexican bulldog, or greater fishing, bat (*Noctilio leporinus*), and the common vampire bat (*Desmodus rotundus*)). This is a reflection of the limited work conducted in the protected area rather than a lack of bat species.

Four rodents were recorded for the protected area – the Yucatan squirrel, Coues’s rice rat, Central American agouti and the paca. The latter in particular is thought to be under serious hunting pressure from hunters using creeks for access, and shooting paca on the creek bank. The ubiquitous grey fox, northern raccoon, and white-nosed coati are all present within the project area. A grison was recorded during the fieldwork, and tayra and neotropical river otter are both reported to be present (G. Tillet, pers. com.). All five of Belize’s cats – jaguar, puma, ocelot, jaguarondi, and margay – are reported as being present. Jaguar tracks were reported from Jones’s Lagoon and a jaguarondi was observed on the Grace Bank road. Jaguars, in particular have come into conflict with the cattle farmers of the Crooked Tree / Biscayne, with predation of cattle, particularly when free ranging.

Tracks and faeces of Baird's tapir indicate that this species is present in the project area. Baird's Tapir (IUCN Red List: Endangered) is becoming increasingly rare throughout its range, with primary threats being deforestation and hunting. Within Belize, it is protected under the Wildlife Protection Act (1981), but is hunted within the project area, though not sold openly in restaurants (Boles, 2017). This species has been impacted significantly by the construction of roads in the lowland pine savannah areas, with increasing reports of road kills, particularly on the Burrell Boom – Hattieville road. At the present time it is thought to be maintaining viable populations within Belize, with the project area playing an important role in the maintenance of crucial habitat.

White-tailed deer are one of the characteristic species of the open pine savannah, and were once widely distributed throughout the area. Hunting pressure used to be seasonal, in the wet season, when rising water levels led to the concentration of game species on higher land; and on the dry season, when hunters would set fire to the savannah to attract deer to the ashes and young grass shoots. Recent reports, however, suggest that as human settlements continue to expand along the roads and hunting pressure increases, game species populations now are much lower than previously, and hunting is not limited to flood times.

The Antillean Manatee (*Trichechus trichechus manatus*) is a globally endangered (IUCN, 2017) regional sub species of the West Indian manatee (Trichechus trichechus). Belize has a national population estimated at between 700 and 1,000 individuals, based on an aerial survey count of 507 individuals in 2014 (Auil, pers. com.), and is considered critical to the maintenance of this species in the region. It is present in the Belize River and appears occasionally in the Crooked Tree lagoon system during wet season, when the water levels are high, entering via Black Creek (which is in the project area. Traditional threats used to include slaughter for food, but since the advent of the Wildlife Protection Act in 1981, interfering in any way with this mammal is illegal. Current threats are boat collisions, particularly in the Belize River, and snagging in fishing nets (particularly in Black Creek, where illegal nets are sometimes stretched across the creek).

The landscape is highly influenced by humans, with increasing human-wildlife conflict. Jaguar sometimes prey on cattle, causing significant financial loss to local farmers, particularly in the Crooked Tree area. Baird's tapir, white-nosed coati, and white-tailed deer may raid milpas, reducing financial sustainability of arable crops. Some mammal species, however, have a positive impact on the communities along the highway – the Yucatan black howler monkeys, for example, provide a tourism resource that attracts tourists to the area.

4.9.7.5 Fish of the study Area

Twenty nine species of fish, representing 10 families, have been reported in the wetlands and rivers of the PGH project area, based on field observations, discussions with fishers encountered, and distribution maps of sample sites used by Greenfield and Thomerson (1997) (Boles, 2017). Two invasive species, *Tilapia mussambicus* and *T. miloticus*, are well established in the rivers, streams, and lagoons of the area, and in some instances, may hybridize (Boles, 2017).

The fish biodiversity has in the past been maintained largely by the seasonal variations in water flow, which have supported a large and healthy population. There is a baseline of freshwater species that inhabit the main lagoon systems and creeks, retreating to creeks (Black Creek and Spanish Creek) and smaller, deeper pools as water drains out of the main system during the dry season. As water depth increases, following the onset of wet season, and the system floods, these fish then restock the wetland areas, with breeding activity in many being triggered by the water changes following the first heavy rains and flooding. Water continues to enter the system, inundating the lagoons and spreading out into the logwood and savannah areas.

With increasing water depth, other species start entering the lagoons from the Belize River - tarpon (*Megalops atlanticus*), vaca (*Ictalurus furcatus*) and snook (*Centropomus undecimalis*) among them. These species are normally more closely associated with estuarine conditions, and gradually disappear from the system when the water flow starts to reverse and the system starts to dry up once again.

This cycle has maintained the wetland fish fauna of the area in the past. In recent years, however, this balance has been altered by a number of major impacts - the construction of the road and a number of causeways, blocking water flow, and the arrival of invasive tilapia in 1985.
Tilapia (both *Oreochromis niloticus* and *Tilapia mussambicus*) were first noted in small numbers in the lagoon system in 1985. This species has spread throughout Meso-America following its introduction for aquaculture, and subsequent accidental release (in Belize, primarily due to hurricane flooding). It has been determined that eradication of this invasive alien species would be impossible, and fisheries targeted at preferentially catching tilapia was put forward as a management option, to maintain reduced tilapia levels within the system.

By 2004, preliminary survey results show a major shift in species composition in the cichlid species assemblage within the Crooked Tree wetland system, with 80% or more of net catch being composed of tilapia (pers. ob., local com.). Local reports were of significant decreases in the *Petenia* population, and a virtual crash in that of *C. friedrichsthali*, which is now rarely caught. Decreasing size of *C. uropthalmus* was also commented on by 100% of the fishermen surveyed, as was a general perception that the native cichlid species appeared 'thin'. Similar experiences have been documented in Nicaragua, where the biomass of native cichlids has been reduced by 80% as a result of the establishment of tilapia. It has been recorded as eradicating underwater vegetation, destroying feeding and breeding niches, and promoting outbreaks of parasites among native fish species (Howard, date). More recently, however, it is thought that the fish populations have reached a balance, with the gradual return of local species.

4.9.7.6 Wildlife Survey Methodology

The methodology used to develop a checklist of the wildlife species occurring in the study site was to actively look for wildlife presence. This activity included five canoe trips in sections of Black Creek, the Belize River, Jones Lagoon, and Mussel Creek. The trips were timed during crepuscular periods of early dawn between 5 a.m. to 8:00m am and dusk between 5:00 p.m. to 11:30 p.m. Important habitats and corridors were also identified and these were searched for wildlife and wildlife tracts by a team of four wildlife enthusiasts. Extensive walks, during different times of the day and under varying weather conditions (hot dry, rainy and after heavy rains) were also carried out through the marshes, savannahs, thicket forests, corridors and riparian areas.   Another methodology used was to quietly sit listen and observed wildlife in known wildlife habitats.

Interviews with villages from Burrell Boom, Sand Hill, and Gardenia were also made. Questions were simple such as what species of birds, mammals, crocodiles and other wildlife do you commonly see? Do you eat bush meat? How often? What types? Do you have problems with wildlife? Do know of others that have problems with wildlife?

4.9.7.7 Results

A total of 370 bird species have been recorded in the study area. This represents an estimated 61% of the total bird species that have been recorded in Belize. Passeriformes that include tanagers, flycatchers, warblers, finches, sparrows, wrens, swallows, thrushes, and vireos were the highest order recorded with 43 species in 16 families. For Amphibians 17 species in 7 families were recorded.   Seven orders of 28 species in 11 families were recorded for fishes. *Poeciliidae* was mostly commonly recorded with 10 species in three families.

For mammals 28 species in 18 families within 9 orders were recorded. It is important to note that the five cat species have been recorded in the study area. Annex IX shows a checklist for birds, amphibians and reptiles, mammals and fishes.

4.10 Water, Noise and Air Quality Sampling

4.10.1 Water Quality

The YSI Professional Plus Water probe (See Annex X) was used to conduct in situ water analysis and The National Drinking Water Quality Monitoring Program -Public Health Bureau laboratory was used to conduct chemical and bacteriological analysis (Table 4.20).

Table 4.20: Water samples taken in the project area.

#	Samples[1, 2, 3]	Description	Easting	Northing	Date Sampled 2017		
1	YSI -Lab C1	Jones Lagoon	350272	1956000		16/3	26/4
2	YSI C1a	Jones Lagoon	350027	1955843		16/3	
3	YSI C1b	Jones Lagoon	349873	1955769		16/3	
4	YSI C1c	Jones Lagoon	349713	1955702		16/3	
5	YSI C1d	Jones Lagoon	349605	1955660		16/3	
6	YSI S4-Big Culvert[4]	Big metal culvert 22.5 mi. Stagnant Water.	349208	1955113	17/2		
7	YSI -Lab BC 1	Upper Wash Pan, Black Creek #1.	341980	1957554		17/3	
8	YSI -Lab BC 2	Wash Pan, Black Creek (Croc Land Farm Road).	344533	1955920		17/3	
9	YSI BC 3	Upper Wash Pan, Black Creek #3.	343323	1956617		17/3	
10	YSI BC 4	Black Creek confluence with Belize River at May Pen.				17/3	
10	YSI-Lab C2	Black Creek before May Pen Wooden Bridge.	347080	1953273		16/3	26/4
11	YSI MP Bridge	May Pen Bridge, Black Creek. Bridge is being repaired.	346962	1953147			26/4
12	YSI-Lab C3 (Mexico Cr.)	Mexico Creek at Grace Bank and Davis Bank wooden bridge.	351617	1951997		16/3	
13	YSI-Lab C4 (Mexico Bridge)	Mexico Creek, Mexico Bridge.	351951	1952633	17/2	16/3	26/4
14	YSI - Lab MC1	Mussel Creek #1. Unable to continue up Mussel creek due to debris.	351411	1950740		22/3	26/4
15	YSI -Lab MC2	Mussel Creek#2.	351075	1951341		22/3	
16	YSI-Lab BR1	Belize River between Mussel Creek and Mexico Creek confluences.	351259	1951739			26/4
17	YSI Dbl Run (BWSL)	Double Run, Belize River where BWSL extracts water for Belize City and surrounding communities.	353519	1948506	17/2		
18	YSI Burrell Boom	Burrell Boom, Belize River.	352390	1943366	17/2		
[1] YSI = In situ analysis only.		[2, 3] YSI-Lab= In situ and laboratory Analysis:	Sampled Once		Sampled Twice		
[4]YSI S4-Big metal Culvert water sample was stagnant water hence it was not used in the comparison.							

Four areas were sampled twice and both in situ and laboratory analysis were conducted at Jones Lagoon, Black Creek, Mexico Creek, and Mussel Creek. Five areas were sampled once and both in situ and laboratory analysis were conducted. The sampling areas included Upper Wash Pan and Wash Pan on Black Creek, Mexico Creek at Grace Bank and Davis Bank wooden bridge, Mussel Creek near the confluence with Belize River and the Belize River between Mussel Creek and Mexico Creek confluences with the Belize River. In addition, 10 in situ samples were taken, four samples were taken at Jones lagoon, one at a the big metal culvert, three samples at upper Black Creek (Wash Pan area) and one at the May Pen wooden bridge, and one each at Double Run and Burrell Boom. The water at the big metal culvert was stagnant water and therefore was not included in the general discussion, as it would skew the data.

Water samples for laboratory chemical and bacteriological analysis followed Standard Methods SOPs when being collected, preserved in ice and transported (in less than 24 hours from the time the first sample was collected) to the Belize Public Health Bureau Laboratories for chemical and biological tests. Table 4.21 provides a listing of the acceptable potable water standards and guideline values (also called **maximum contaminant level (MCL))** from Belize Water Services Limited (BWSL) and the World health Organization (WHO) Guidelines.

Table 4.21: Acceptable potable water standards and guideline values.

Parameter	BWSL	WHO	Remarks on water quality parameters
Coliform (total)	0/100 ml	0/100 ml	
E-coli	0/100 ml	0/100 ml	
Temperature	25˚C	none	
pH	6.5 – 7.5	6.5 – 8.5	Value of 7 indicates a neutral condition
Conductivity	N/A	none	Range of 50-1500 µS/cm found in natural surface water
TDS	500 mg/l	1,000 mg/l	TDS of 0-1000 mg/L is considered fresh and non-saline
Turbidity	5 units	5 NTU	Pure distilled water turbidity is 0 NTU
Hardness (total)		none	**Soft: 0 to 60 mg/l Moderately hard: 61 to 120 mg/l** **Hard: 121 to 180 mg/l Very hard: > 180 mg/l** Less than 120 mg/L is deemed desirable, in excess of 500 mg/L undesirable for domestic and industrial use.
Alkalinity	250 mg/l	N/A	Generally acceptable water quality range for alkalinity is 30-500 mg/L
Nitrate–Nitrogen NO_3 - N	10 mg/l	10 mg/l	
Phosphate PO_4	N/A	none	
Sulphate- SO_4	250 mg/l	250 mg/l	Concentrations up to 500 mg/L acceptable
Iron -Fe	0.3 mg/l	0.3 mg/l	

N/A = Not Available. Source: NARMAP Environmental Water Quality Monitoring Program: Final Report and Annexes, DOE/USAID, June 1995

4.10.2 Baseline Water Quality Results

See Annex XI for Baseline Water Analysis Results

Fecal *Coliform* and *Escherichia Coli*

Coliform bacteria, found naturally in the intestines of warm-blooded animals, is the major sub-group of the total coliform family of a large assemblage of various species of bacteria that are linked together because of the ease of culturing as a single group. Fecal coliform include both pathogenic, or disease-causing species, and non-pathogenic species. The presence of fecal coliform in any water body is an indication of fecal material contamination from human and/or animal waste. Sources of fecal contamination to surface waters include wastewater, on-site septic systems, domestic and wild animal manure, and storm runoff.

Escherichia coli, commonly called *E. coli*, is a sub-group of the fecal coliform group and it is also a normal component of the large intestines in humans and other warm-blooded animals.

The first set of six (6) analysis showed that all sample sites showed the presence of fecal coliform and only five (5) had presence of *E. coli*. Black Creek (before the May Pen wooden bridge) and Mexico Creek at Grace Bank and Davis Bank wooden bridge showed the highest fecal coliform at 110 and 100 count/ml respectively, and *E. coli* at 100 and 90 counts /100 ml respectively. Jones Lagoon showed the lowest count of fecal coliform at 10 counts/100 ml but zero presence of *E. coli.* The second set of samples analyzed on four (4) previous sites and on one (1) additional site, the Belize River between Mussel Creek and Mexico Creek, showed that Black Creek, Mexico Creek and Belize River waterways tested positive for both fecal coliform and *E. coli.* There was not much difference in counts among these sites. Both Jones Lagoon and Mussel Creek tested negative for both fecal coliform and *E. coli.*

Laboratory analysis does not identify if the presence of fecal contamination is from either human or animal waste. In the sampled areas, there are human activities (bathing, fishing, farming, and homes near banks) as well as pastures with herds of cattle and wildlife presence, which very likely contribute to the presence of fecal coliform in the waterways sampled.

Because some of these samples tested positive for fecal coliform and *E. coli*, persons using these waters, should exercise caution when using these water especially if it is a source of drinking water. The WHO Guideline for Total Fecal Coliform in drinking water is 0 counts/100ml. Any water that tests positive for fecal *coliform*/*E. coli* and that will be used for drinking and other domestic purposes must always be treated first to remove these organisms to make the water safe for use.

Temperature

Surface water temperature is a measure of the amount of heat present in water. Aside from dissolved oxygen, temperature is considered the single most important constituent influencing aquatic life. Knowledge of water temperature is essential to the measurement of dissolved oxygen (decreases as temperature increases), conductivity (salinity) (increases as temperature increases), and pH (the entire pH range shifts from high to low as temperature increases). The sampled water temperature oscillated from a minimum of 24.6˚C at Jones Lagoon to a maximum of 28.6˚C at Mexico Creek during late February and the month of March with an average of 27.5˚C. However in late April (the onset of the dry season) the minimum water surface water temperature had increased by 1.8˚C to 30.4˚C (Mussel Creek) and the maximum of 36.4˚C was recorded in the Belize River between the Mussel Creek and Mexico Creek confluences. The Maximum was recorded at 1:30 pm well within the hottest time of the day–10am to 3pm. The average temperature recorded that day was 32.3˚C.

pH

pH or "potential of hydrogen" is the measurement of the acidic or basic/alkaline condition in the water. This basically refers to the amount of hydrogen found in the water. The pH is measured on a logarithm scale from 0 - 14, with 7 being neutral. The general classification of the scale is that a pH of less than 7 indicates acidic condition, whereas a pH of greater than 7 indicates a basic or alkaline condition. The normal pH range for surface water is 6.5-8.5

All lab analysis recorded that pH was well within the acceptable range for surface waters with the lowest pH readings of 7.27 (1^{st} Analysis) and 7.1(2^{nd} Analysis) at Mexico Creek (north of Bridge) and the maximum pH of 8.73 (1^{st} Analysis) and 8.52 (2^{nd} Analysis) at Jones Lagoon.

All of the pH values found throughout the sampling locations indicate that the waters are slightly alkaline to alkaline in nature.

Conductivity

The ability or power of an aqueous solution to carry or transmit an electrical current is reported as Conductivity. In water and ionic fluids a net motion of charged ions can occur. This phenomenon produces an electric current and is called ionic conductance. Pure water is not a good conductor of electricity. Because the electrical current is transported by the ions in solution, the conductivity increases as the concentration of ions increases. The specific conductance of the samples was measured by a self-contained conductivity electrode in the laboratory. Conductivity is typically standardized at 25˚C as it is temperature sensitive.

The water at all sampling locations showed low conductivity (below 5 mS/cm) readings with the exception of Jones Lagoon, which recorded in situ readings of 4 – 5 mS/cm and lab reading of 4.74 in March 2017. During the April 17 analysis both Jones Lagoon and Black Creek saw an increase in conductivity while the Mexico Creek and Mussel Creek saw a decrease.

Most streams have a fairly constant range of conductivity under normal circumstances. Therefore, significant changes in conductivity can be an indicator that a discharge or some other source of pollution has entered the water. The composition of the water can be critical for aquatic organisms as well, as many critters have very specific ranges that they can tolerate.

Total Dissolved Solids

Total dissolved solids or TDS is basically a measure of the total dissolved ionic activity that is occurring in the water body. Conductivity and total dissolved solids are reasonably comparable. The TDS of a water sample based on the measured electrical conductivity (EC) value can be calculated using the following equation:

TDS (mg/l) = 0.5 x EC (dS/m or mmho/cm) or = 0.5 * 1000 x EC (mS/cm)

Similarly like conductivity all the waters sampled showed low at all locations showed that there is low dissolved ionic activity present in these surface water bodies with the exception of Jones Lagoon with the highest TDS of 3853.5 mg/L (in situ-Mar 2017), 6272.5 mg/L (in situ-April 26, 2017) and 2,390 mg/L (lab Mar 2017), 4,410 mg/L (lab-April 26, 2017) and the lowest found was in the Black Creek showing a TDS of 0.37 mg/L (in situ-Mar 2017), and Mexico Creek showing the lowest at 702.1 mg/L (in situ-April 26, 2017). For March 2017, Black Creek showed the lowest lab reading of 379 mg/L while Belize River between the Mussel Creek and Mexico Creek confluences showed the lowest lab reading of 366 mg/L April 2017 lab analysis.

Turbidity

Turbidity is the measurement of relative clarity of a liquid. It is an optical characteristic of water and is an expression of the amount of light that is scattered by material in the water when a light is shined through the water sample. The higher the intensity of scattered light, the higher is the turbidity.

Examples of the materials that cause water to be turbid include clay, silt, finely divided inorganic and organic matter, algae, soluble coloured organic compounds, and plankton and other microscopic organisms. Increases in turbidity will cause water to become cloudy or opaque.

In streams, increased sedimentation and siltation can occur, which can result in harm to habitat areas for fish and other aquatic life. Particles also provide attachment places for other pollutants, for e.g. bacteria. For this reason, turbidity readings can be used as an indicator of potential pollution in a water body.

The lab analysis conducted in March 2017 indicated that the maximum turbidity was 14.6 and 13.9 NTU for the Upper Black Creek and Wash Pan, Black Creek respectively. In April 2017, the Belize River reported the maximum of 16.1 NTU. Jones Lagoon recorded the lowest turbidity on both analysis dates; however, the April analysis was greater than that of the March 2017 analysis. All other samples reported turbidity lower than 10 NTU. A noticeable dark colour from wood tannins was observed in the Black Creek and Mussel Creek.

Total Hardness

There are two predominant ions that are responsible for hardness in water and these are calcium and magnesium. Waters with a high hardness concentration leads to more use of soap as it takes a longer time to generate lather and increase hardness can also lead to a "build up" of scale in boilers, shower heads, etc. The general guidelines for classification of hardness of waters are shown in Table4.31.

In examining the laboratory results, it can be seen that in all locations the water can be classified as very hard above 180mg/l. Jones Lagoon in both March 2017 and April 2017 showed highest counts. It should be pointed out that increased water hardness has been shown to reduce the toxicity of some substances to aquatic organisms. This relationship is well established for certain metals (Jayaraj et al., 1992; Gundersen et al., 1994; Galvez and Wood, 1997; Perschbacher and Wurts, 1999; Hansen et al., 2002) cited in Davis 2006).

Alkalinity

Alkalinity refers to the capability of water to neutralize acid. This basically means the water capacity to resist changes in the pH which would make the water more acidic.

The alkalinity of natural water is determined by the soil and bedrock through which it passes. The main sources for natural alkalinity are rocks which contain carbonate, bicarbonate, and hydroxide compounds. Borates, silicates, and phosphates also may contribute to alkalinity. Limestone is rich in carbonates, so waters flowing through limestone regions or bedrock containing carbonates generally have high alkalinity - hence good buffering capacity. Conversely, areas rich in granites and some conglomerates and sandstones may have low alkalinity and, therefore, poor buffering capacity.

Alkalinity is important for fish and aquatic life because it protects or buffers against rapid pH changes. Living organisms, especially aquatic life, function best in a pH range of 6.0 to 9.0. Alkalinity is a measure of how much acid can be added to a liquid without causing a large change in pH. Higher alkalinity levels in surface waters will buffer acid rain and other acid wastes and prevent pH changes that are harmful to aquatic life.

All sampling locations had water, which fell within the acceptable ranges of 30 to 250 mg/l. Therefore, all water bodies have some sort of buffering capacity. The highest alkalinity concentration was Mussel Creek and Belize River while the lowest alkalinity concentration was at Jones Lagoon and Mexico Creek.

Nitrate- Nitrogen

Nitrogen is naturally occurring element that is essential to plant growth and crop production. However, nitrate N can cause eutrophication of surface waters primarily by stimulating algae production. Also excessive concentrations of nitrate-nitrogen or nitrite-nitrogen in drinking water can be hazardous to health, especially for infants and pregnant women.

The major sources of nitrates in water are run-off from fertilizer use, septic tank leakage, animal manure, and release from natural deposits. The MCL for nitrate-nitrogen is 10 mg/l.

Despite the presence of pasture land and wildlife along the Mussel Creek, Black Creek and the Belize River banks, nitrate-nitrogen concentration found at all these locations was very low. The highest of 1.6 mg/l and 1.3 mg/l of nitrate-nitrogen was found at Mussel Creek in March 2017 and 1.6 mg/l for Mussel Creek and Belize River in April 2017. The lowest concentration of 0.8mg/l for Jones Lagoon and Upper Black Creek was found in March 2017. However, in April 2017, Jones Lagoon and Mussel Creek both reported 1.0 mg/l. The lower reading of the nitrate-nitrogen at Mussel Creek could be as a result of the herd of cattle which was present near the banks of this creek in March were in a different pastured section further away and nearer to the Belize River bank in April.

Phosphate

Phosphate stimulates the growth of plankton and aquatic plants which provide food for larger organisms, including zooplankton, fish, humans, and other mammals. Plankton represents the base of the food chain. Initially, this increased productivity will cause an increase in the fish population and overall biological diversity of the system. But as the phosphate loading continues and there is a build-up of phosphate in the surface water ecosystem, the aging process of a surface water ecosystem will be accelerated. Excessive nutrient inputs, usually nitrogen and phosphate, have been shown to be the main cause of eutrophication.

Phosphorous occurs naturally in the rocks and other mineral deposits. During the natural process of weathering the rocks release the phosphorous as phosphate ions. Phosphates exist in 3 forms one of which is orthophosphate which is the form that was measured in the laboratory to the sampling locations. There is no MCL for phosphate in potable water since phosphates are not toxic to people or animals unless they are present in very high levels. Digestive problems could occur from extremely high levels of phosphate (Water Research Center, 2017).

In analyzing the lab results from the March 2017 water samples it showed that the sample locations had very low concentration of phosphate ranging from 0.03 mg/l to 0.05 mg/l and in April 2017, although the concentration had an increase, the range was from 0.06 mg/l to 0.11 mg/l.

Sulphate

Sulphate (SO_4) can be found in almost all natural water. The origin of most sulphate compounds is the oxidation of sulphite ores, the presence of shales, or the industrial wastes. Sulphate is one of the major dissolved components of rain. High concentrations of sulphate in the water we drink can have a laxative effect and, in combination with other ions, give water a bitter taste. A MCL for sulphate is set for 250 mg/l but 500 mg/l is acceptable.

Some sampling sites had greater concentration than the MCL. March 2017 and April 2017 results show that Jones Lagoon had the highest concentration of sulphate at 525 mg/l and 1,200 mg/l respectively. Mexico Creek followed this with 500 mg/l and 475 mg/l at its two locations in March 2017 and Black Creek before the May Pen Bridge saw an increase from 225 mg/l in March 2017 to 675 mg/l in April 2017. The lowest, 175 mg/l was reported for March 2017 at the upper Black Creek at the two Wash Pan areas sampled. In April 2017, Mexico Creek reported the lowest reading at 125 mg/l. Mussel Creek did not show major concentration shift when both sampling dates are compared.

Total Iron

Iron occurs naturally in soil, sediments, and groundwater and can be found in many types of rocks. Iron can be present in water in two forms; the soluble ferrous iron or the insoluble ferric iron. Water containing ferrous iron is clear and colourless, and when exposed to air the water turns cloudy causing a reddish brown precipitate of ferric iron appears.

Iron exists naturally in rivers, lakes, and underground water. It may also be released to water from natural deposits, industrial wastes, refining of iron ores, and corrosion of iron containing metals. The combination of naturally occurring organic material and iron can be found in shallow wells and surface water. This water is usually yellow or brown but maybe colourless.

The iron concentration that was found at all sampling locations was negligible at all replicated samples showed iron concentration below the SML of 0.3 mg/l. The two samples taken in March 2017 of the Upper Black Creek in the Wash Pan area, the iron was not detected as the concentration was below the detection limit (0.01mg/l) of the UV/VIS Spectrophotometer.

Dissolved Oxygen

Dissolved oxygen analysis measures the amount of oxygen dissolved in water. The actual amount of dissolved oxygen present will be dependent on temperature, pressure, and salinity.

More dissolved oxygen is present in water with both lower temperature and salinity compared to water with both higher temperature and salinity. The reason for this inverse relationship between dissolved oxygen and temperature/salinity is that the solubility of a gas in a liquid is an equilibrium phenomenon. Very low concentration of dissolved oxygen in a water body is detrimental to aquatic life as it could lead to fish kill. The minimum amount to sustain aquatic life is around 4 -5 ppm

The dissolved oxygen concentration in the preliminary site visit of February 2017, the in situ sampling was within the acceptable range even at the Big Culvert sampling point, which was stagnant water (N.B. This sampling point is not included in the comparison of the other parameters). In March 2017, Jones Lagoon exhibited the highest reading with an average of 7.08 ppm in five sampling points. This concentration remained almost the same for April 2017 at an average of 7.65 ppm. The March 2017, the in situ reading at the sampling points of Black Creek before the May Pen Bridge and at Mexico Creek Bridge was an average of 3.7 ppm and 3.05 ppm, respectively below the MCL. In April 2017, only Mexico Creek Bridge showed a decline in DO concentration, while Black Creek's DO concentration improved above MCL. The sample taken of the Belize River for this same date (April 2017) indicated a very low DO concentration of 2.85 ppm. At this sampling point, the recorded water temperature was 36˚C (the highest) and low salinity of 0.72 ppt, temperature a possible dominant contributor to low DO concentration. The same could be said of with Mexico Creek Bridge's average low DO reading of 2.21 ppt, at an average temperature of 31.55˚C and average low salinity of 0.535 ppt.

Salinity

Salinity is the measure of all the salts dissolved in water. Salinity is usually measured in parts per thousand (ppt). The average ocean salinity is 35 ppt and the average river water salinity is less than 5 ppt and for drinking water is 0.5 ppt or less. This means that in every kilogram (1000 grams) of seawater, 35 grams are salt.

In analyzing, the salinity data that was recorded in situ in February, March, and April 2017, at all sampling locations the water at each of these locations is freshwater as the salinity found ranged from 0.37 ppt to 6.36 ppt. It should be pointed out that salinity increased at Jones Lagoon, Black

Creek and Mussel Creek and the Belize River from March to April 2017 while Mexico Creek the salinity decreased.

4.10.3 Noise Pollution

4.10.3.1 Noise Pollution

Former U.S. Surgeon General William H. Stewart said in 1978, "Calling noise a nuisance is like calling smog an inconvenience. Noise must be considered a hazard to the health of people [and animals] everywhere."

Noise pollution is not easy to measure, because the very definition of noise depends on the context of the sound and the subjective effect it has on the people hearing it. One person's idea of exultant, joyful music might be another person's pure torment.

Noise refers to sounds in the environment that are caused by humans and that threaten the health or welfare of human or animal inhabitants. Animals rely on meaningful sounds for communication, navigation, avoiding danger and finding food against a background of noise (Fox, 2017). Noise is also defined as "any human sound that alters the behaviour of animals or interferes with their functioning" The level of disturbance may be qualified as damage (harming health, reproduction, survivorship, habitat use, distribution, abundance, or genetic distribution) or disturbance (causing a detectable change in behaviour) (USDT-FHA, 2017).

While noise emanates from many different sources, transportation noise is perhaps the most pervasive and difficult source to avoid in society today. Highway traffic noise is a major contributor to overall transportation noise (USDT-FHA, 2017). The noise of road vehicles is mainly generated from the engine and from frictional contact between the vehicle and the ground and air. In general, road contact noise exceeds engine noise at speeds higher than 60 km/h. Special problems can arise in areas where the traffic movements involve a change in engine speed and power, such as at traffic lights, hills, and intersecting roads (Berglund & Lindvall, (Eds.) 1995).

The literature review indicates that ambient noise level is normally below or about 40 decibels (dB). Therefore, levels that exceed this can be considered as noise pollution. Exposure to high decibel noise of an intensity of 85 dB or more for long hours can result in some adverse effects on human health. Noise disrupts sleep and communication, and numerous studies have documented the heart-related, respiratory, neurological, and other physiological effects of noise. Stress, high blood pressure, anger and frustration, lower resistance to disease and infection, circulatory problems, ulcers, asthma, colitis, headaches, gastrointestinal disorders, and many other physiological and psychological problems have been linked directly to noise.

Livestock and pets are also harmed by noise, as are animals in the wild. Noise can also disturb wildlife feeding and breeding. Noise pollution disrupts animals' navigation instincts and makes it difficult for them to be aware of predators. Birds living in areas where noise is rampant in the day time but absent at night change their singing patterns and sing at night when it is quiet.

Noise-related property damage includes structural damage from vibrations induced by sound waves and economic harm in the form of lower property values.

Noise levels as well as its noise duration will invariable increase during and after the rehabilitation of the Philip Goldson Highway in the following ways:

- Increase in road construction equipment traffic and personnel transportation.
- Quarrying (away from construction site) and its associated activities of excavation, and transportation of road material from existing material pits to the project.
- Increase of traffic to the project area as a result of the rehabilitation of the highway.

Reduction of road traffic noise can be achieved through reduction of noise at source and of noise transmission through improved traffic management, and by control of receptor noise levels through non-vehicular measures, (land-use planning, roadside noise barriers, and insulation in residential areas, and improvement of road surfaces). Reengineering machines and simply turning down volume when possible are methods of reduction at the source. A reduction in the length of exposure can be used to supplement the previous measures, if necessary. This may be accomplished by job rotation or by restricting the operation of the noise source. Hearing protectors are the least desirable option from the standpoint of preventing damage. However, if it is absolutely impossible to reduce noise to a harmless level then some form of hearing protection device (i.e., ear-plug, ear-muffs, and/or helmets) is necessary (Berglund & Lindvall, (Eds.) 1995).

Table 4.22 provides a summary of the noise levels normally produced by different equipment against ambient noise levels and standards.

Table 4.22: Noise levels of Common Sources.

Source of Sound	Distance from Source (m)	Sound Pressure Level Decibels (dB)
Ambient and Standard Noise Levels		
Ambient noise level		40 or less
Normal conversation face to face	1	40 -60
EPA-maximum to protect against hearing loss		70
WHO Maximum –Industrial Work Place		75
Less than for bedroom for good night rest		30
Less than for classroom teaching		35
Construction Noise Levels		
Air Compressor	15	81
Backhoe	15	80
Chainsaw	1	110
Compactor (Plate)	15	101
Concrete Mixer	15	85
Crane Mobile	15	83
Dozer	15	85
Generator	15	81
Grader	15	85
Impact Wrench/Pneumatic Tool	15	85
Jack Hammer	15	88
Loader	15	85
Paver	15	89
Pile Driver (Impact)	15	101
Pump	15	76
Roller	15	74
Saw	15	76
Tractor without cab	15	120
Traffic (Heavy Equipment)	10	90
Traffic (Heavy Traffic)	15	80-89
Traffic (motorcycle/ATV)	15	96-100
Traffic (Passenger car at 65 mph)	10	77
Truck (Dump)	15	88
Truck (Pickup)	15	75

4.10.3.2 Results of Noise Level Sampling

Eleven (11) sampling points were identified and 14 samples were taken within the project area on April 28, 2017, focusing primarily on intersections and schools areas during the morning commute en route to Belize City from 6:00 am to 10:30 am. Noise levels were measured using a Sper Scientific Digital Sound Level Meter 840028, a full function Type 2[8] sound meter (See Annex X). The results are shown in Table 4.33.

The ambient and minimum noise level at the Mile 24.2 –Biscayne sampling point was the lowest at 41.5 dBA and 35.3 dBA respectively. The highest reading at 99.5 dBA was at the Vista del Mar Junction. This junction also recorded the highest ambient and minimum noise levels. The higher levels of noise recorded at the Vista del Mar Junction is attributed to the heavy traffic flow at the early morning hour due to persons travelling to Belize City for work and school reasons. It was also observed that the duration of high noise level lasted for almost the entire 10 minutes sampled due to bottle necks caused by speed bumps, before and after the junction and augmented by the narrow carriage way (due to the newly installed wide median). Drivers also tend to accelerate after clearing the speed bump. Only two residential building are located in this area. The Philip Goldson Airport Junction also had high noise levels, at this early time of the day, but the duration was less. This can be attributed to a free flow of vehicular traffic due to the absence of speed bumps even though the carriage way was narrowed by a median.

Of the school areas sampled, the ambient noise level recorded were in the range of 48 dBA to 66.6 dBA, the minimum recorded were 45.2 dBA to 55.6 dBA and the maximum recorded were 81.7 dBA to 94.8 dBA. The observation indicate that Ladyville Technical High School also had a long duration of high noise level which can be attributed to the frequent passenger school buses stopping to unload students and taking off only to immediately slow down to cross a speed bump. The nearest school building however is located some 200 meters from the highway. Ladyville Evangelical School noise level was also prolonged as it lies between three busy road intersections (Ladyville, Lords Bank and Lake Gardens). Here the nearest building to the highway is about 23 meters.

[8] Meets IEC651Type 2, ANSI S1.4 Type 2

In conclusion, the project area has high noise levels at specific times of the day from the Vista del Mar intersection to the Lake Gardens intersection, the most populated section of the road (Section 1) which can be considered as somewhat harmful to the environment (humans and fauna). It should be noted that of all vehicular traffic, with a few exceptions, the passenger busses, tractor trailers (tow heads) and dump trucks (ten wheelers) tended to record a higher noise level when compared to other vehicular traffic.

4.10.4 Air Pollution (Dust and Emissions)

During the site visits to the project area during the months of February to April 2017, which is the ending of the rainy season and the onset of the dry season, dust was not a problem since the road is already paved. Where dust was visible observed been suspended in the air was when vehicular traffic veered into the unpaved shoulder to unload and unload passengers etc. This however was for very short periods.

During road construction, quarrying and its associated activities of excavation, and transportation increase the suspended particulate matter in the air and so does the traffic on roads, whose pavements are being removed and prepared for rehabilitation, especially during the dry season. These airborne dusts are of particular concern because they are well known to be associated with classical widespread occupational diseases such as the pneumoconiosis, cancer, asthma, allergic alveolitis, and irritation, as well as a whole range of non-respiratory illnesses, which may occur at much lower exposure levels.

4.10.4.1 Scientific Instruments used

The following scientific instruments were used to gather the baseline data on ambient air: a) Casella MicroDust Pro- Particulate Monitor for particulate matter and b) BW Technologies by Honeywell Gas Alert Multi-Gas (4) Meter for hydrogen Sulphide (H_2S), carbon monoxide (CO), Oxygen (O_2) and combustible gases (%LEL) (See Annex X).

4.10.4.2 Results of Particulate Matter Sampling

Long-term exposure to high levels of fine particles in the air contributes to a range of health effects, including respiratory diseases, lung cancer, and heart disease, resulting in 4.2 million deaths annually. Not only does exposure to air pollution affect the health of the people, it also carries huge economic costs and represents a drag on development, particularly for low and middle income countries and vulnerable segments of the population such as children and the elderly (Brauer et al. 2016). According to the World Health Organization, most of these deaths occurred in low- and middle-income countries.

In 2010, the fifth leading cause of premature death in the developing world and the third highest environmental health risk was ambient air pollution. Invariably the poor suffer the most because they have fewer options to move to cleaner neighbourhoods or take protective measures.

The particles most likely to cause adverse health effects are the *fine particulates* PM10 particles smaller than 10 microns in aerodynamic diameter. The United States Environmental Protection Agency (US-EPA) uses its Air Quality Index to provide general information to the public about air quality and associated health effects. An Air Quality Index (AQI) of 100 for any pollutant corresponds to the level needed to violate the federal health standard for that pollutant. An AQI of 100 for PM_{10} corresponds to a PM_{10} level of 150 micrograms per cubic meter (averaged over 24 hours) (Table 4.23.)

Table 4.23: Particulate Matter Health Hazard (PM10 µg/m³).

EPA Index	Health Concern	PM_{10} Particles up to 10 micrometers in diameter (PM_{10})
0 - 50	Good	None
51 - 100	Moderate	None
101 - 150	Unhealthy for Sensitive Groups	People with respiratory disease, such as asthma, should limit outdoor exertion.
151 - 200	Unhealthy	People with respiratory disease, such as asthma, should avoid outdoor exertion; everyone else, especially the elderly and children, should limit prolonged outdoor exertion.
201 - 300	Very Unhealthy	People with respiratory disease, such as asthma, should avoid any outdoor activity; everyone else, especially the elderly and children, should limit outdoor exertion.
301 - 500	Hazardous	Everyone should avoid any outdoor exertion; people with respiratory disease, such as asthma, should remain indoors.

Source: US-EPA https://www.airnow.gov/index.cfm?action=pubs.index

Based on the World Bank's two-ten year averages and the 2011 estimated concentration of Particulate Matter (PM10) for Belize (Table 4.24), there was no health concern with Particulate Matter concentration during those years when compared to the EPA Particulate Matter Health Hazard table.

Table 4.24: Particulate Matter Concentrations (PM10) World Bank Estimates.			
	Avg	Avg	
Country Name	**1991-2000**	**2001-2010**	**2011**
	micrograms per cubic meter (µg/m3)		
Belize	**20.37**	**20.05**	**17.98**
Data Source: http://data.worldbank.org/indicator/EN.ATM.PM10.MC.M3/countries/1W?display=graph			

For the project area, 11 sites were sampled in April 28, 2017, of which fourteen maximum readings were observed during a period of 1 minute-intervals ranged from as low as 0 µg/m^3 at the Burrell Boom, Guadalupe RC School and Pancotto Methodist School to highs of 758 µg/m^3 and 526 µg/m^3 at the Ladyville Technical High School (second reading) and Vista del Mar Junction (First Reading) respectively. The sampling was done during periods of traffic flow as no detectable levels were recorded during other periods.

The average readings ranged from as low as 0 µg/m^3 at six locations, namely at Lady of Our Way School, Ladyville Evangelical School, Burrell Boom, Guadalupe RC School, Pancotto Methodist School and Gardenia Mile 22. Both the Vista del Mar Junction (First and Second Readings) and the Ladyville Technical High School (second reading) recorded the highest average readings of 178 µg/m^3, 139 µg/m^3, and 150 µg/m^3 respectively. Both sample points with the highest maximum and average readings had very heavy traffic flow during the 1 minute-period sampled.

It is also worthy to note that bush fires have been observed along the project road especially in the savannah areas near the Mexico Creek Bridge during the dry season (February to May). During BET's visit a bushfire was observed just before Mexico Creek Bridge (See Figure 4.53). It is assumed that during these occurrences the PM10 in these affected areas are relatively high.

Figure 4.53: Top: Drone bush fire near Mexico Bridge. Bot.: Close-up of bush fire. Source: BET March 12, 2017.

In conclusion, it should be noted that the sampling duration was only for a short period of ten (10) minutes. Notwithstanding this, a straight comparison with EPA indexes (Table 4.23), the maximum readings are considered relatively high and hazardous to health and the average readings can be classified as unhealthy for sensitive groups to unhealthy albeit for only a 10 minute exposure during a heavy traffic flow. Also, the sampling shows that nine maximum readings and six of the average readings exceeded that of the World Bank's two-ten year averages and the 2011-estimated concentration of Particulate Matter (PM10) for Belize (Table 4.24).

4.10.4.3 Results of Gases Sampling

The detection of hydrogen Sulphide (H_2S), carbon monoxide (CO), and combustible gases (%LEL) were zero indicating the ambient air quality is essentially very clean. Oxygen level at all sites was 20.9%, which is the naturally occurring concentration in atmospheric air (Table 4.25). This result is expected as the ambient air in these areas is almost free of pollutants and the flow of traffic is for the most part intermittent. The only way one would be able to detect CO, SOx and NOx at levels that the instruments could record these would be to place these at the end of the vehicles exhausts.   At this stage these gases are of minor concern and no appreciable increase in their levels can be expected.

The time limitations for the gathering of baseline data on these air emission pollutants resulting from vehicular emissions did not allow for the use of diffusion tubes (that could be ordered from abroad) and perhaps would have rendered more useful information than the gas detectors which were available to the team.

Measurement of the low concentrations found outdoors normally requires large, expensive instruments. It would have been best if colorimetric, passive diffusion tubes for sampling periods of several weeks or months were evaluated to measure the suspected very low concentrations of these gases present in Belize's ambient air quality in these areas. Diffusion tubes for CO, H_2S, NO_2, SO_2, and benzene could be obtained at some later point by DOE to gather baseline information on these gases.

Annex XII provides the results of diffusion tubes used to monitor the concentration of BTEX (benzene, toluene, ethyl benzene, and xylenes), nitrogen dioxide, and hydrogen sulphide along the Southern Highway, the Hummingbird Highway, and the George Price Highway by Belize Natural Energy. The results all showed very low concentrations recorded in parts per billion after almost one month of exposure time.

Table 4.25: Results of Noise Level, Gases and Particulate Matter-PM10 Sampling on the Philip Goldson Highway Miles 8.5 to 24.5.

Date: 28 April, 2017			UTM Coordinates (WGS84 Datum)		Noise				Gases				Particulate Measurement-PM10		Remarks
WP#	Time[1]	Location			Ambient	Min	Max	Other[2]	H_2S	CO	O_2	LEL	Max	Avg	
					dBA				mg/m³				µg/m3		
N&A 1	6:35 am	Start of Project: Mile 8.5 Vista Del Mar Junction	363826.00	1940320.00	70.1	62.7	94.5	91.3 Bus 76.6 P'up Sm. 86.0 Motor cycle 76.1 Toyota SUV 87.0 Bus (Morales)	0.0	0.0	20.9	0.0	526	178	Rush hour for morning commute to Belize City. Constant vehicular traffic. Speed bumps before and after junction, therefore vehicles tend to accelerate after passing the bump. Max noise due to passenger bus
	6:50 am				70.5	62.0	99.5	70.0 Sm. Car 94.8 Bus 91.3 Bus 82.5 SUV	0.0	0.0	20.9	0.0	300	139	Max noise due to passenger bus
N&A 2	6:57 am	Philip Goldson Airport Junction	363249.62	1940481.98	61.7	60.0	98.4	90.5 Bus 91.0 Motor Cycle 82.5 Bus 89.0 SUV 76.0 P'up sm. 73.0 Sm. Car	0.0	0.0	20.9	0.0	437	72	Max noise due to motor cycle (cheery bomb muffler). No speed bump on both sides of junction. There is a road divider in front of junction.
	7:10 am				65.0	60.0	82.0	72.9 SUV 89.5 Bus 77.0 SUV 80.0 SUV 86.8 Bus	0.0	0.0	20.9	0.0	437	84	Max due to cargo truck Both max particulate measurement are attributed to condition of road and speed of vehicular traffic
N&A 3	7:15 am	Lady of Our Way RC School	362228.86	1940658.47	60.1	52.9	88.4	87.5 Motor Cycle 85.8 Bus 77.0 Truck 77.0 SUV Chevy 69.0 Motor cycle 75.0 Motor cycle 85.3 Bus (Greyhound type)	0.0	0.0	20.9	0.0	36	0	Max noise due to passenger bus. Traffic volume was lower than at 6:40 am. School Hours 8:30 am to 3:30 pm. Speed bumps before and after school, therefore vehicles tend to accelerate after passing the bump. Several drivers do not respect zebra crossing or school speed limit. Max particulate matter can be attributed to condition of road and accelerating after the bump.

Table 4.25 (Cont.): Results of Noise Level, Gases and Particulate Matter-PM10 Sampling on the Philip Goldson Highway Miles 8.5 to 24.5.

Date: 28 April, 2017			UTM Coordinates (WGS84 Datum)		Noise				Gases				Particulate Measurement-PM10		Remarks
WP#	Time[1]	Location			Ambient	Min	Max	Other[2]	H_2S	CO	O_2	LEL	Max	Avg	
					dBA				mg/m³				μg/m3		
N&A 4	7:25 am	Ladyville Technical High School	361447.66	1941048.26	66.6	52.6	94.8	80.1 Truck 76.5 Motor Cycle 66.5 P'up sm. 82.8 Bus 81.9 Bus 83.6 Bus 80.5 Tractor trailer	0.0	0.0	20.9	0.0	470	54	Max Noise due to a tractor-trailer. Ladyville Technical High School is approximately 200 meter off the highway. Majority of buses reduced speed when approaching junction and stopped at junction to drop off students, hence lower noise level. The speed bump was after the high school junction going towards Belize City, bus drivers tended easy their way over the bump from their stationary position.
	7:37 am												758	150	Both max particulate measurements are attributed to busy junction as buses stop to unload students off the road pavement and take off.
N&A 5	7:50 am	Ladyville Evangelical School	360996.35	1941550.47	58.6	55.6	91.1	87.9 Tractor-trailer 74.5 Belikin Tractor trailer 70.5 P'up sm. 73.8 Bus 72.2 Bus	0.0	0.0	20.9	0.0	1	0	Max noise due to Dump Truck. School is near highway. Speed bumps are located approximately 100 meter from gate on both ways. Traffic was lower in volume at this hour.
N&A 6	8:12 am	Burrell Boom Junction	356761.06	1944774.44	58.0	56.8	89.4	72.5 P'up Ford sm. 80.4 Cargo truck 69.5 SUV Prado 87.5 Bus	0.0	0.0	20.9	0.0	0	0	Max noise due to Bus. Bump some 35 meters north of junction.
N&A 7	8:30 am	Guadalupe RC School	354836.00	1949631.00	48.0	45.2	81.7	67.0 SUV Toyota 62.0 P'up Ford sm.	0.0	0.0	20.9	0.0	0	0	Max noise due to Bus. Bump some 20 meters south of school. School buildings were 75 meters from roadside.
N&A 8	8:55 am	Pancotto Methodist School	354775.46	1949848.68	56.7	50.8	90.8	74.8 Car sm. 77.2 SUV	0.0	0.0	20.9	0.0	0	0	Max noise due to Dump Truck. No Speed bumps or school signage. Noise mostly from children playing in the yards just before classes begin. School building is approximately 15 meters form road side

Table 4.25 (Cont.): Results of Noise Level, Gases and Particulate Matter-PM10 Sampling on the Philip Goldson Highway Miles 8.5 to 24.5.

Date: 28 April, 2017			UTM Coordinates (WGS84 Datum)		Noise				Gases				Particulate Measurement-PM10		Remarks
WP#	Time[1]	Location			Ambient	Min	Max	Other[2]	H_2S	CO	O_2	LEL	Max	Avg	
					dBA				mg/m^3				μg/m3		
N&A 9	9:14 am	Sand Hill / Old Northern Highway Junction	354705.78	1950660.02	55.0	40.0	90.4	82.5 Zeta Ice Delivery Truck 79.9 Van 74.6 P'up Isuzu 87.8 Coca cola Tractor-trailer 78.1 Car sm. 85.9 Butane Fuel Truck 68.9 Bus stationary unloading passenger	0.0	0.0	20.9	0.0	248	17	Max noise due to Ford F150 P'up. Speed bump some 50 meters north from the junction. Max particulate reading is attributed to bus unloading passenger
N&A 10	9:45 am	Mile 22 Gardenia	349757.00	1953957.00	43.0	35.7	94.8	92.1 Bus (Tillet) 85.7 Cargo Truck 86.5 SUV Jeep 90.2 P'up Chevy lg. 89.1 Van Chevy	0.0	0.0	20.9	0.0	1	0	Max noise and Max particulate measurement is attributed to the Tractor-trailer with bulldozer.
N&A 11	10:00 am	Mile 24.2 Biscayne	348066.00	1957213.00	41.7	35.3	90.5	84.6 SUV Prado 88.5 Van Chevy 87.9 P'up Hilux 89.6 Tractor-trailer	0.0	0.0	20.9	0.0	55	1	Max noise due to Bus.

[1] Sampling at intervals of 1 minutes. [2]Random Sampling of passing vehicles.

Figure 4.54: Noise and Air Sampling Point N&A1 Vista del Mar Junction.

Figure 4.55: Noise and Air Sampling Point N&A2 Philip Goldson Highway Junction.

Figure 4.56: Noise and Air Sampling Point N&A3 Lady of Our Way RC School.

Figure 4.57: Noise and Air Sampling Point N&A4 Ladyville Technical Highschool.

Figure 4.58: Noise and Air Sampling Point N&A5 Ladyville Evangelical School.

Figure 4.59: Noise and Air Sampling Point N&A6 Burrel Boom Junction and N&A7 Guadalupe RC School.

Figure 4.60: Noise and Air Sampling Point N&A8 Pancoto Methodist School.

Figure 4.61: Noise and Air Sampling Point N&A9 Sand Hill / Old Northern Highway Junction.

Figure 4.62: Noise and Air Sampling Point N&A10 Mile 22 Gardenia.

Figure 4.63: Noise and Air Sampling Point N&A10 Mile 24.2 Biscayne.

CHAPTER 5: SOCIAL SETTINGS

This Chapter of the ESIA provides a description of the existing social environment of the defined Study Area and is underpinned by an analysis of key demographic characteristics, social infrastructure, social values, and lifestyles using established indicators. The baseline provides the platform from which to identify potential social impacts the community may face, or changes that may occur to the existing social environment by introducing the proposed Road Rehabilitation Project and enables the identification of effective strategies to help mitigate the negative while maximizing the positive impacts associated with the Project.

5.1 Methodology

The Social Baseline component of the ESIA Study utilized a mixed method approach and relied on the use of primary data derived from a carefully targeted survey and right-of-way census and complemented by key informant interviews, focus group discussions and direct field observations over the period March-April, 2017. Additionally, these primary data sources were further complemented by secondary data derived from the 2010 Census and relevant literature review of the Study Area comprising the villages as specified in Table 5.1.

Table 5.1: Road Sections and Communities in Study Area.

Road Section	Village
RS I: Section from Mile 8.5 – Mile 15	Ladyville
	Lord's Bank
RS II: Section from Mile 15 – Mile 24.5	Sandhill
	Gardenia
	Biscayne

Direct Field Observations: To better understand the dynamics of the project affected communities, albeit a snapshot of community life, time was dedicated observing various sporting events in Ladyville, Lord's Bank and Sandhill as well as observing the daily routines of adults going to work and children going to school and the respective transportation and road safety issues associated with the existing road conditions across the five communities.

Key Informant Interviews and Focus Group Discussions: To deepen the understanding of issues observed, a number of key informant interviews were conducted with educators, village residents, and local entrepreneurs. Additionally, focus group discussions were also conducted with the respective village councils to inform on the proposed road rehabilitation and to ascertain an overall qualitative understanding of the socio-economic development from their perspective and document key issues currently impacting their communities as well as potential impacts as a consequence of the proposed road rehabilitation.

Social Baseline Survey and ROW Census: The Social Baseline Survey targeted a random sample of households in each identified village using the PPS method and a 95% confidence level and 6% margin of error. The face-to-face Survey was conducted by 12 trained interviewers over the period April 3 - 13, 2017 using a semi-structured questionnaire, Annex XIII.

Table 5.2: Social Baseline Survey Response Distribution.

HH located along ROW?	Result of HH Interview:	CTVC?					Total
		Ladyville	Sandhill	Lord's Bank	Gardenia	Biscayne	
Yes	completed	31	62		29	20	142
	no one at home	1	1		0	0	2
	partially completed	2	5		0	2	9
	vacant dwelling/lot	1	0		0	0	1
	no suitable respondent	0	1		0	0	1
	Total	35	69		29	22	155
No	completed	102	27	50	5		184
	no one at home	1	0	0	0		1
	refusal	0	0	1	0		1
	partially completed	2	0	2	0		4
	Total	105	27	53	5		190
Total	completed	133	89	50	34	20	326
	no one at home	2	1	0	0	0	3
	refusal	0	0	1	0	0	1
	partially completed	4	5	2	0	2	13
	vacant dwelling/lot	1	0	0	0	0	1
	no suitable respondent	0	1	0	0	0	1
	Total	140	96	53	34	22	345

The census of households was conducted simultaneously alongside the Survey and targeted all households along the right-of way, adjusting for households already included in the Survey sample listing. As detailed in Table 5.2, overall response rate for the Survey and Census is 94.5% and 85.5% for the Survey alone.

5.2 Findings: Ladyville Village

Administratively in the Belize District, Ladyville Village as a population centre is located 8 miles northwest of Belize City within a natural flood plain being low lying and just north of the Belize River and adjacent to the Caribbean Sea. It is interconnected to the Old Capital by the Phillip Goldson Highway which cuts through the Village. Ladyville consists of several smaller communities, inter alia: Vista Del Mar, Old Site, Mitchell Estate, Perez Estate, Japan, Lake Gardens, Bainton's Bank Area and Los Lagos.

What follows is a summary baseline profile of the Village as it relates to:

- Population Size and Structure,
- Demographics,
- Governance, Social Cohesion and Community,
- Public Utilities,
- ICT,
- Education,
- Health,
- Crime,
- Land and Dwelling Occupancy,
- Unemployment and Workers' Category,
- Poverty Distribution.
-

Population Size, Growth, and Structure: The 2010 population Census recorded a population count of 5,458 residents and 1,527 households. The female population slightly outnumbered that of the males with a male:female sex ratio of 0.96. The average annual intercensal population growth for Ladyville is estimated at 5% well above the estimated 3% national rate. This places the 2016 estimated population at around 7,000 residents and 2000 households making Ladyville the largest village in the country (BET, 2017).

Ladyville's population structure is best characterized as an "expansive population pyramid" given its rapidly growing pre-reproductive population age grouping (0-14 years). The current sex ratio is estimated at 0.97 suggesting an overall small increase in the number of resident males relative to the 2010 Census as a possible consequence of an increase in the life expectancy for men as they seem to now be living longer. Notwithstanding this, the numbers of females continue to outnumber the males, with marked differences across the reproductive age cohorts, 15-44 years, Table D-1[9].

Demographics: Ladyville is predominantly a Creole community. Creoles are by far the major ethnic group, comprising 57% of the population followed by Mestizos which comprise 28%, Table D-2. While Chinese remain an ethnic minority grouping, their presence has been growing steadily over the past decade. English and Creole are the most widely spoken languages followed by Spanish.

With respect to union status, 57% of residents are not in a union; when adjusted for the proportion of children in the Village, 35% being children, this leaves 22% of adults not in a union. A further 2% are in a visiting relationship, 16% in a common-law union and 23% married and living with their spouse, Table D-3.

Governance, Social Cohesion and Community Life: Subject to the provisions of the Village Council Act Chapter 88 of the laws of Belize, Ladyville, like other established villages, has a duly elected 7-member Council, a female chairperson and 3 female and 3 male councillors serving the residents for the period 2016-2019. Additionally, the Area Representative for the Belize Rural Central electoral constituency has been identified as having great influence over the affairs and decisions relating to the Village, which is characterized as a double edge sword by the Council: support on one hand and micromanagement on the other with very strong autocratic-transactional leadership traits (FGD, 2017).

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[9] Refer to Annex XI: Social Baseline Survey of the Rehabilitation of the Philip Goldson Highway Miles 8.5 to 24.5 for tables labelled alphanumerically e.g. Table D-1.

As is customary in community life in Belize, politics and religion permeate all levels of society and walks of life. Ladyville is no exception as the Village now finds itself highly polarized across political and religious lines; especially in a time when the political currents are more overt and charged, especially leading up to village council and national elections.

Notwithstanding this political polarization, the residents of Ladyville enjoy much sporting activities (basketball, football, softball,) either as amateur athletes or spectators with a strong competitive spirit. To this end, the Village meets with various community sporting assets: football field, basketball court, parks, and playgrounds.

While the population centre records the numbers usually associated with township in Belize, it lacks the necessary socio-economic policy and legal underpinnings for balanced development and growth. Ladyville is home to the only international airport in the country, headquarters of the Belize Defence Force and the British Army Training Support Unit Belize (BATSUB) and home to Belize's only brewing company and Coca Cola franchise. In recent years, Ladyville has seen an increase in the number of retail merchandise and service-oriented businesses (banks, air-conditioning, fuel stations, telecommunication, construction, etc.) that have set up operations, particularly given the stiffer tax regime in Belize City. While some residents have gained local employment as a result, many others commute via private and public transport into Belize City.

Notwithstanding this level of economic activity, tax benefits do not accrue to the Village with the exception of shared liquor licensing fees resulting in a very strong dependence on Central Government subventions and reinforcing the role of the Area Representative. In terms of social infrastructure and services, the Village boasts a community centre, local fire station, police station and a health centre, the latter of which is currently being expanded through support from the US Army Core of Engineers and the MOH (KII, 2017).

Public Utilities and Sanitation: The vast majority of households in Ladyville, 97% rely on the national grid managed by BEL for their electricity needs; the remaining 3% resort to other sources, inter alia lamps, candles and solar, Table U-1.

Likewise, most households, 83%, rely on BWS for general household water usage. The remaining proportion makes use of either rain water or BWS piped-water, Table U-2. In contrast, bottled water remains the primary source for drinking also at 83% followed by BWS piped water at 14% and rainwater at 3%, Table U-3.

To this end and given that water lines and electricity poles are located within the road reserves as is customary, careful planning and notification to community residents and business establishments will be required to minimize disruptions and prepare for planned outages.
In Ladyville, 86% of households make use of flush toilets to septic tanks and the remainder some variation of pit latrines, Table U-4.

A good majority of households make use of the available private garbage disposal services, 3 providers, at a monthly rate of BZ$15.00; others take their garbage to the Burrell Boom transfer station and a few households resort to burning or illegal dumping (FGD, 2017)

ICT: In Ladyville, 93% of residents report cell phone ownership, Table ICT-1. DigiCell as a service provider outnumbers their competitor, SMART, by a factor of 4, Table ICT-2. Eighty-three per cent (83%) of residents indicate satisfaction with their service provider as measured by the quality of service (good/very good) and full reception (talk/text/data), Table ICT3 and ICT4. With respect to internet access, 77% of residents indicate having access, Table ICT-5, 89% of which access the internet directly from their homes while others do so from friends/family/work /internet cafes, Table ICT-6.

Education: In Ladyville, 31% of the residents are currently attending some form of schooling, Table ED-1; of those not currently attending school, 12% have completed less than a primary level education, 29% primary-level, 22% secondary-level, 2% VOTECH, 9% sixth-form level and 9% university level, Table ED-2.

In terms of education infrastructure, Ladyville is home to 4 preschools, three primary schools, 1 secondary school, and 1 VOTECH training centre. Residents and educators alike rate the overall performance of schools at average. Furthermore, on a daily basis, a significant number of residents commute via public and private transport to and from Belize City for secondary and tertiary level educational services (KII, 2017).

Health: Generally and outside of minor colds and occasional treatment for asthma, the residents of Ladyville appear in overall good health; additionally, no major outbreaks associated with dengue, malaria or cholera was reported (KII, 2017).

While residents across the Village appear in general good health, a number of residents report, being affected by the presence of chronic illnesses (non-communicable diseases (NCD)) primarily among the older population and to a lesser extent mature adults. Principal among these NCD are: diabetes (14%), hypertension (9%), asthma (9%), arthritis/rheumatism (5%), cancer (3%) and cancer/anaemia/heart disease (5%), Table H-1.

With respect to disabilities, an estimated 2% prevalence rate is detected as measured by the severity scale adopted from the Washington Group on Disability Statistics, i.e. 2% of Ladyville residents are reporting 'lots of difficulty/cannot do at all' as it relates to seeing, hearing, walking/climbing stairs and/or communicating/speaking, Table H-2. For a breakdown of specific disability type, see Tables H-3 – H-7.

In Ladyville, 100% of the residents report having heard of AIDS, Table H-8; however, only 46% have 'comprehensive correct knowledge about HIV prevention', i.e. the proportion of respondents who 'knew of two ways of HIV prevention' AND 'knew that a healthy looking person can have the AIDS virus' AND 'rejected the two most common misconceptions', Table H-9. In addition, only 36% could correctly identify the three ways of mother-to-child transmission of HIV, Table H-10.

Additionally, in terms of health services, Ladyville is home to a health clinic staffed by a full-time general practitioner and a nurse. The Village also benefits from two private providers (Seventh Day Adventist (SDA) Clinic and St. Christopher's Clinic) and in cases of emergency from Price Barracks Army Medics (KII, 2017). Notwithstanding, the majority of residents who have accessed medical services report doing so in Belize City.

Land and Dwelling Occupancy: Three in four Ladyville residents own the home in which they live and the land on which it is located with the remainder renting, Table DW-1. Dwelling type is predominantly undivided private houses, 94%; with the remaining 6% being combined business and dwelling/apartments, Table DW-2.

Crime: Seven per cent (7%) of residents report having been a victim of crime in the past year preceding the Baseline Survey, Table CR-1. Among the leading types of crime to which they are reportedly victims, include: robbery (25%), wounding/assault/harm (25%), manslaughter/murder (13%), shooting (13%), and burglary (13%), Table CR-2.

Unemployment and Category of Workers:

Persons in employment comprise all residents above the age of 14 years who during the week prior to the Survey were either in paid or self-employment. The sample estimate for the economically active population in Ladyville stood at 247 persons with 26 either actively seeking work/did not want to work, Table E-1. To this end, the unemployment rate for Ladyville was estimated at 10.5%. The distribution of workers' categories includes self-employed (25%), paid employee-government (18%), paid employee-private sector/NGO (40%) and unpaid family workers (6%). The remaining proportion did not wish to state their category Table E-2.

Poverty Distribution: In 2012, the Statistical Institute of Belize produced a national poverty map using 2011 data from the Multiple Indicator Cluster Surveys (MICS) and based on the small areas estimation (SAE) technique. As summarized in Table 5.3, Ladyville is characterized as a Village with upper-middle socio-economic status. The relative socio-economic standing of this Village against the national (221 communities) and district (43 communities) rankings are 2nd and 2nd respectively, i.e. the 2nd 'wealthiest' community in the Belize District and in the country overall (SIB, 2012).

Table 5.3: SES Ranking Ladyville

Road Section (RS)	District	Wealth Index Quintiles	Wealth Index Score	SES Ranking	
				National	District
RS-I	Ladyville	4	0.8493	2	2

5.3 Findings: Lord's Bank Village

Administratively in the Belize District, Lord's Bank Village as a population centre is located adjoining Ladyville Village and northwest of Belize City and within a natural flood plain being low lying and just north of the Belize River. It is interconnected to the Phillip Goldson Highway by a service road at approximately mile 9.5 and is one of many early European estates developed along the Belize River for transportation reasons that has evolved into a village (KII, 2017) What follows is a summary baseline profile of the Village as it relates to:

- Population Size and Structure,
- Demographics,
- Governance, Social Cohesion and Community,
- Public Utilities,
- ICT,
- Education,
- Health,
- Land and Dwelling Occupancy,
- Crime,
- Unemployment and Workers' Category,
- Poverty Distribution.

Population Size, Growth, and Structure: The 2010 population Census recorded a population count of 3,140 residents and 884 households. The female population outnumbered that of the males with a male: female sex ratio of 0.93. The average annual intercensal population growth for Lord's Bank is estimated at 10.5% well above the estimated 3% national rate. This places the 2016 estimated population at around 4,200 residents and 1000 households making Lord's Bank one of the fastest growing villages in the country (BET, 2017).

Lord's Bank's population structure is best characterized as an "expansive population pyramid"; however, while its pre-reproductive population age cohort (0-14 years) is growing, the growth rate does not quite match up to that if its neighbour Ladyville. The current sex ratio is estimated at 0.96 suggesting an overall increase in the number of resident males relative to the 2010 Census as a possible consequence of an increase in the life expectancy for men as they seem to now be living longer; notwithstanding, the number of females continue to outnumber the males, with marked differences across the reproductive age cohorts, 15-44 years, Table D-1.

Demographics: The demographic profile for Lord's Bank is similar to that of Ladyville; it is predominantly a Creole community. Creoles are by far the major ethnic group, comprising 68% of the population followed by Mestizos at 22% and Garifuna 8%, Table D-2. While Chinese remain an ethnic minority grouping, their presence has been growing steadily over the past decade. English and Creole are the most widely spoken languages followed by Spanish.

With respect to union status, 50% of residents are not in a union; when adjusted for the proportion of children in the Village, 27% being children, this leaves 23% of adults not in a union. A further 3% are in a visiting relationship, 24% in a common-law union and 22% are married and living with their spouse, Table D-4.

Governance, Social Cohesion and Community Life: Subject to the provisions of the Village Council Act Chapter 88 of the laws of Belize, Lord's Bank, like other established villages, has a duly elected 7-member Council, a male chairperson and 3 female and 3 male councillors serving the residents for the period 2016-2019. Of importance to note is that the Village chairperson ran and won as an independent candidate. The Council reports a good working relationship and cooperation with the Area Representative for the Belize Rural Central electoral constituency (FGD, 2017).

As is customary in community life in Belize, politics and religion permeate all levels of society and walks of life. Lord's Bank is no exception as the Village now finds itself polarized across political and religious lines; albeit the political currents being more overt and charged, especially leading up to village council and national elections.

Notwithstanding this political polarization, the residents of Lord's Bank enjoy much sporting activities (basketball, football, softball, and cricket) either as amateur athletes or spectators with a strong competitive spirit. To this end, the Village meets with various community sporting assets: football field, basketball court and parks and playgrounds. Sports is a usual community activity and positive outlet for the residents of Lord's Bank.

The population centre records numbers associated with one of the larger villages in Belize, it however lacks the commensurate socio-economic policy and legal underpinnings for balanced development and growth. In recent years, Lord's Bank has seen an increase in the number of retail merchandise businesses primarily managed by individuals of Chinese origin although many of the existing snack shops and local food vendors remain locals. Being so close to Ladyville, many residents enjoy local employment in that Village while a great number also commute via private and public transport into Belize City.
In terms of social infrastructure and services, the Village boasts a community centre, and is serviced by the Ladyville local fire station, police station, and health centre (KII, 2017).

Public Utilities and Sanitation: The vast majority of households in Lord's Bank, 98% rely on the national grid managed by BEL for their electricity needs; the remaining 2% resort to other sources, inter alia lamps, candles and solar, Table U-1.

Likewise, all households rely on BWS for general household water usage; in contrast, bottled water remains the primary source for drinking at 80% followed by rainwater at 14% and BWS piped water at 6%., Table U-2

To this end and given that water lines and electricity poles are located within the road reserves as is customary, careful planning and notification to community residents and business establishments will be required to minimize disruptions and prepare for planned outages.
In Lord's Bank, 98% of households make use of flush toilets to septic tanks and the remainder some variation of pit latrines, Table U-3.
A good majority of households make use of the available private garbage disposal services, 2 providers, at a monthly rates of BZ$15.00 and $12.00; others take their garbage to the Burrell Boom transfer station and a few households resort to burning or illegal dumping (FGD, 2017)

ICT: In Lord's Bank, 96% of residents report cell phone ownership; DigiCell as a service provider outnumbers their competitor, SMART, by a factor of 5.5, Table ICT-1 and Table ICT-2. Eighty-three per cent (86%) of residents indicate satisfaction with their service provider as measured by the quality of service (good/very good) and full reception (talk/text/data) Table ICT-3.

With respect to internet access, 78% of residents indicate having access, 85% of which access the internet directly from their homes while others do so from friends/family/work/internet cafes, Table ICT 5 and Table ICT-6.

Education: In Lord's Bank, 29% of the residents are currently attending some form of schooling, Table ED-1; of those not currently attending school, 14% have completed less than a primary level education, 25% primary-level, 32% secondary-level, 2% VOTECH, 14% sixth-form level and 12% university level, Table ED-2.

In terms of education infrastructure, Lord's Bank is home to 1 preschool and an alternative training centre for girls managed by the Youth Enhancement Services (YES). Notwithstanding, Ladyville schools provide the necessary school services with some parents opting for Belize City schools in search of wider options and better quality. To this end, on a daily basis, a good number of residents commute via public and private transport to and from Belize City for primary, secondary, and tertiary level educational services (KII, 2017).

Health: Generally and outside of minor colds and occasional treatment for asthma, the residents of Lord's Bank appear in overall good health; additionally, no major outbreaks associated with dengue, malaria or cholera was reported (KII, 2017).

While residents across the Village appear in general good health, a number of residents report, being affected by the presence of chronic illnesses (non-communicable diseases) primarily among the older population and to a lesser extent mature adults. Principal among these NCD are: diabetes (7%), hypertension (9%), asthma (18%), arthritis/rheumatism (2%), and glaucoma (2%), Table H-1.

With respect to disabilities, an estimated 2% prevalence rate is detected as measured by the severity scale adopted from the Washington Group on Disability Statistics, i.e. 2% of Lord's Bank residents are reporting 'lots of difficulty/cannot do at all' as it relates to seeing, hearing, walking/climbing stairs and/or communicating/speaking, Table H-2. For a breakdown of specific disability type, see Tables H-3 – H-7.

In Lord's Bank, 98% of the residents report having heard of AIDS, Table H-8; however, only 51% have 'comprehensive correct knowledge about HIV prevention', i.e. the proportion of respondents who 'knew of two ways of HIV prevention' AND 'knew that a healthy looking person can have the AIDS virus' AND 'rejected the two most common misconceptions', Table H-9. In addition, only 55% could correctly identify the three ways of mother-to-child transmission of HIV, Table H-10.

While Lord's Bank does not have a health clinic of its own, it shares services with Ladyville which is home to a health clinic staffed by a full-time general practitioner and a nurse. In addition, Ladyville also has access to services from two private providers (SDA Clinic and St. Christopher's Clinic) and in cases of emergency from Price Barracks Army Medics (KII, 2017). Notwithstanding, the majority of Lord's Bank residents who have accessed medical services, report doing so in Belize City.

Dwelling Occupancy and Type: Sixty-four per cent of Lord's Bank residents own their home in which they live and the land it is located on with the remainder renting, Table DW-1. Dwelling type is predominantly, undivided private houses, 98%; with the remaining 2% being apartments, Table DW-2.

Crime: Seventeen per cent (17%) of residents report having been a victim of crime in the past year preceding the Baseline Survey, Table CR-1. Among the leading types of crime to which they are reportedly victims, include: home invasion (21%), robbery (14%), wounding/assault/harm (14%), manslaughter/murder (14%), sexual assault (14%), domestic violence (14%) and burglary (7%), Table CR-2.

Unemployment and Category of Workers:

Persons in employment comprise all residents above the age of 14 years who during the week prior to the Survey were either in paid or self-employment. The sample estimates for the economically active population in Lord's Bank stood at 91 persons with 13 either actively seeking work/did not want to work, Table E-1. To this end, the unemployment rate for Ladyville was estimated at 14.3%. The distribution of workers' categories includes self-employed (18%), paid employee-government (21%), paid employee-private sector/NGO (35%) and unpaid family workers (2%). The remaining proportion did not wish to state their category Table E-2.

Poverty Distribution: In 2012, the Statistical Institute of Belize produced a national poverty map using 2011 data from the MICS and based on the small areas estimation (SAE) technique. As summarized in Table 5.4, Lord's Bank is characterized as a Village with upper-middle socio-economic status. The relative socio-economic standing of this Village against the national (221 communities) and district (43 communities) rankings are 9th and 4th respectively, i.e. the 4th 'wealthiest' community in the Belize District and 9th in the country overall (SIB, 2012).

Table 5.4: SES Ranking Lords Bank.

Road Section (RS)	District	Wealth Index Quintiles	Wealth Index Score	SES Ranking	
				National	District
I	**Lords Bank**	**4**	**0.7202**	**9**	**4**

5.4 Findings: Sandhill Village

Administratively in the Belize District, Sandhill Village as a population centre and one of the mainland villages spans approximately from miles 15 (RHS of the Boom junction) – 22 along the Philip Goldson Highway. What follows is a summary baseline profile of the Village as it relates to:

- Population Size and Structure,
- Demographics,
- Governance, Social Cohesion and Community,
- Public Utilities,
- ICT,
- Education,
- Health,
- Land and Dwelling Occupancy,
- Crime,
- Unemployment and Workers' Category,
- Poverty Distribution.

Population Size, Growth and Structure: The 2010 population Census recorded a population count of 1,843 residents and 508 households. The female population outnumbered that of the males with a male:female sex ratio of 0.98. The average annual intercensal population growth for Sandhill is estimated at 4.0% well above the estimated 3% national rate. This places the 2016 estimated population at around 1,890 residents and 520 households (BET, 2017).

Sandhill's population structure is best characterized as an "expansive population pyramid" with an increasing pre-reproductive population age cohort (0-14 years). The current sex ratio is estimated at 0.87 suggesting an overall decrease in the number of resident males relative to the 2010 Census as a possible consequence of a decrease in the life expectancy for men. To this end women continue to outnumber men with mark differences across the reproductive and post-reproductive age cohorts Table D-1.

Demographics: Sandhill is predominantly a Creole community. Creoles are by far the major ethnic group, comprising 84% of the population followed by Mestizos at 11%, Table D-2. English and Creole are the most widely spoken languages followed by Spanish to a lesser extent. With respect to union status, 54% of residents are not in a union; when adjusted for the proportion of children in the Village, 30% being children, this leaves 24% of adults not in a union. A further 3% are in a visiting relationship, 14% in a common-law union and 29% are married and living with their spouse, Table D-4.

Governance, Social Cohesion and Community Life: Subject to the provisions of the Village Council Act Chapter 88 of the laws of Belize, Sandhill, like other established villages, has a duly elected 7-member Council, a male chairperson and 3 female and 3 male councillors serving the residents for the period 2016-2019. The Council reports a strained working relationship with the Area Representative for the Belize Rural North electoral constituency, with very little support forthcoming given the political affiliation of the Council (FGD, 2017).

As is customary in community life in Belize, politics and religion permeate all levels of society and walks of life. Sandhill is no exception as the Village now finds itself polarized across political and religious lines; albeit the political currents being more overt and charged, especially leading up to village council and national elections. This is also true during the course of normal business as the council is a Peoples United Party (PUP) declared majority and the Area Representative from the United Democratic Party (UDP).

Notwithstanding this political polarization, the residents of Sandhill enjoy much sporting activities (basketball, football, and softball) either as amateur athletes or spectators with a strong competitive spirit. To this end, the Village has various community sporting assets: football field, basketball court and parks and playgrounds located on the Village Grounds at mile 18. Sport is a usual community activity and positive outlet for the residents of Sandhill.

The population centre records numbers associated with an average size villages and growth, it however lacks the commensurate socio-economic policy and legal underpinnings for enhanced development and growth. In terms of social infrastructure and services, the Village boasts a community centre, and is serviced by a police sub-station. The sub-station does not meet with 24/7 staffing and in cases of emergency, residents have to rely on Ladyville police. This is reported as a regression from previous years when the station was staffed with a resident officer. The Village also lacks a health clinic, but is served by a rural health nurse who treats with minor cases. For more serious medical needs, residents travel to Belize City (KII, 2017).

Public Utilities and Sanitation: The vast majority of households in Sandhill, 97% rely on the national grid managed by BEL for their electricity needs; the remaining 3% resort to other sources, inter alia lamps, candles and solar, Table U-1.

Likewise, all households, 100%, rely on BWS for general household water usage, Table U-3. To this end and given that water lines and electricity poles are located within the road reserves as is customary, careful planning and notification to community residents and business establishments will be required to minimize disruptions and prepare for planned outages.
In Sandhill, 93% of households make use of flush toilets to septic tanks and the remainder some variation of pit latrines, Table U-4.

A good majority of households make use of the available private garbage disposal services, at a monthly rate of BZ$18.00; others take their garbage themselves to the Burrell Boom transfer station and a few households resort to burning or illegal dumping (FGD, 2017).

ICT: In Sandhill, 94% of residents report cell phone ownership, Table ICT-1. DigiCell as a service provider outnumbers their competitor, SMART, by a factor of 5, Table ICT-2. Eighty per cent (80%) of residents indicate satisfaction with their service provider as measured by the quality of service (good/very good) and full reception (talk/text/data) Table ICT-3.

With respect to internet access, 77% of residents indicate having access, 82% of which access the internet directly from their homes while others do so from friends/family/work/internet cafes, Table ICT 5 and Table ICT-6.

Education: In Sandhill, 29% of the residents are currently attending some form of schooling, Table ED-1. Of those not currently attending school, 7.3% have completed less than a primary level education, 33% primary-level, 32% secondary-level, 5% VOTECH, 11% sixth-form level and 7% university level, Table ED-2.

In terms of education infrastructure, Sandhill is home to one preschool and two primary schools (RC and Methodist). A small number of parents choose to have their children attend primary school in Belize City due to quality issues. In addition and given the absence of secondary and tertiary level education services in the Village, many youth commute on a daily basis to Ladyville/Belize City via public and private transport for educational services (KII, 2017).

Health: Generally and outside of minor colds and occasional treatment for asthma, the residents of Sandhill appear in overall good health; additionally, no major outbreaks associated with dengue, malaria or cholera was reported (KII, 2017).

While residents across the Village appear in general good health, a number of residents report, being affected by the presence of chronic illnesses (non-communicable diseases) primarily among the older population and to a lesser extent mature adults. Principal among these NCD are: diabetes (7%), hypertension (13%), asthma (8%), arthritis/rheumatism (18%), kidney disease (2%), cancer (2%) and anaemia (2%), Table H-1.

With respect to disabilities, an estimated 4% prevalence rate is detected as measured by the severity scale adopted from the Washington Group on Disability Statistics, i.e. 4% of Sandhill residents are reporting 'lots of difficulty/cannot do at all' as it relates to seeing, hearing, walking/climbing stairs and/or communicating/speaking, Table H-2. For a breakdown of specific disability type, see Tables H-3 – H-7.

In Sandhill, 96% of the residents report having heard of AIDS, Table H-8. However, only 50% have 'comprehensive correct knowledge about HIV prevention', i.e. the proportion of respondents who 'knew of two ways of HIV prevention' AND 'knew that a healthy looking person can have the AIDS virus' AND 'rejected the two most common misconceptions', Table H-9. In addition, only 40% could correctly identify the three ways of mother-to-child transmission of HIV, Table H-10.

Sandhill does not have any health clinic of its own; however, it does have the services of one health nurse who provides services for minor conditions during normal working hours. For emergency purposes residents must seek medical attention in Belize City (KII, 2017).

Dwelling Occupancy and Type: Eighty per cent of Sandhill residents own their homes in which they live and the land it is located on with the remainder renting, Table DW-1. Dwelling type is predominantly, undivided private houses, 92%; with the remaining 8% being combined business/dwelling/part of a private house, Table DW-2.

Crime: Seventeen per cent (10%) of residents report having been a victim of crime in the past year preceding the Baseline Survey, Table CR-1. Among the leading types of crime to which they are reportedly victims, include: home invasion (27%), robbery (18%), wounding/assault/harm (9%), manslaughter/murder (18%), and burglary (18%), Table CR-2.

Unemployment and Category of Workers:

Persons in employment comprise all residents above the age of 14 years who during the week prior to the Survey were either in paid or self-employment. The sample estimates for the economically active population in Sandhill stood at 132 persons with 15 either actively seeking work/did not want to work, Table E-1. To this end, the unemployment rate for Sandhill was estimated at 11.4%. The distribution of workers' categories includes self-employed (25%), paid employee-government (21%), paid employee-private sector/NGO (38%), paid employee-INGO/embassy (3%) and unpaid family workers (3%). The remaining proportion did not wish to state their category, Table E-2.

Poverty Distribution: In 2012, the Statistical Institute of Belize produced a national poverty map using 2011 data from the MICS and based on the small areas estimation (SAE) technique. As summarized in Table 5.5, Sandhill is characterized as a Village with upper-middle socio-economic status. The relative socio-economic standing of this Village against the national (221 communities) and district (34 communities) rankings are 17th and 7th respectively, i.e. the 7th 'wealthiest' community in the Belize District and 17th in the country overall (SIB, 2012).

Table 5.5: SES Ranking Sandhill

Road Section (RS)	District	Wealth Index Quintiles	Wealth Index Score	SES Ranking	
				National	District
RS-Ii	Sand Hill	4	0.5759	17	7

5.5 Findings: Gardenia Village

Administratively in the Belize District, Gardenia Village as a population centre is located at mile 23 on the Phillip Goldson Highway. What follows is a summary baseline profile of the Village as it relates to:

- Population Size and Structure,
- Demographics,
- Governance, Social Cohesion and Community,
- Public Utilities,
- ICT,
- Education,
- Health,
- Land and Dwelling Occupancy,
- Crime,
- Unemployment and Workers' Category,
- Poverty Distribution.

Population Size, Growth, and Structure: The 2010 population Census recorded a population count of 303 residents and 78 households. The male population outnumbered that of the females with a male:female sex ratio of 1.15. The average annual intercensal population growth for Gardenia is estimated at 1.7% well below the estimated 3% national rate. This places the 2016 estimated population at around 310 residents and 80 households (BET, 2017).

Gardenia's population structure is best characterized as an "expansive population pyramid" with an increasing pre-reproductive population age cohort (0-14 years). Of importance to note is that there are missing males in the mature adult cohort (45-49 years) as well as in the elderly cohorts (60+), albeit more pronounced for the female cohorts. Perhaps this is best explained by migration of many of the residents in the pre-independence era who were in "search of a better life" as well as lower life expectancy. The current sex ratio is estimated at 1.08 suggesting an overall decrease in the number of resident males relative to the 2010 Census as a possible consequence of a decrease in the life expectancy for men. To this end women continue to outnumber men with marked differences across the reproductive and post-reproductive age cohorts (15-44 years), Table D-1.

Demographics: The demographic profile for Gardenia is similar to that of Ladyville; it is predominantly a Creole community. Creoles are by far the major ethnic group, comprising 84% of the population followed by Mestizos at 9% and Garifuna 3%, Table D-2. English and Creole are the most widely spoken languages followed by Spanish to a lesser extent.
With respect to union status, 53% of residents are not in a union. When adjusted for the proportion of children in the Village, 37% being children, this leaves 16% of adults not in a union. A further 2% are in a visiting relationship, 21% in a common-law union and 22% are married and living with their spouse, Table D-4.

Governance, Social Cohesion and Community Life: Subject to the provisions of the Village Council Act Chapter 88 of the laws of Belize, Gardenia, like other established villages, has a duly elected 7-member Council, a male chairperson and 6 female councillors serving the residents for the period 2016-2019. The Council reports a good working relationship and cooperation with the Area Representative for the Belize Rural North electoral constituency (FGD, 2017).

As is customary in community life in Belize, politics and religion permeate all levels of society and walks of life. Gardenia is no exception as the Village now finds itself polarized across political lines with the political currents being more overt and charged, especially leading up to village council and national elections. Notwithstanding this political polarization, the residents of Gardenia enjoy much leisure and relaxation time. The social infrastructure in the Village is very thin and leaves much room for development (KII, 2017).

Public Utilities and Sanitation: All the households in Gardenia rely on the national grid managed by BEL for their electricity needs, Table U-1.

Likewise, most households, 76%, rely on BWS for general household water usage; the remaining proportion make use of rain water (6%), rivers/streams (6%) and wells (6%), Table U-3.
To this end and given that water lines and electricity poles are located within the road reserves as is customary, careful planning and notification to community residents and business establishments will be required to minimize disruptions and prepare for planned outages.

In Gardenia, 91% of households make use of flush toilets to septic tanks and the remainder some variation of pit latrines, Table U-4.

Households in Gardenia for the most part use their garbage as filling; while others resort to burning; since no public/private sanitation services are available to residents (FGD, 2017).

ICT: In Gardenia, 91% of residents report cell phone ownership, Table ICT-1. DigiCell as a service provider outnumbers their competitor, SMART, by a factor of 4, Table ICT-2. Fifty-eight per cent (58%) of residents indicate satisfaction with their service provider as measured by the quality of service (good/very good) and full reception (talk/text/data) Table ICT-3.

With respect to internet access, 70% of residents indicate having access, 84% of which access the internet directly from their homes while others do so from friends/family/work/internet cafes, Table ICT-5 and Table ICT-6.

Education: In Gardenia, 32% of the residents are currently attending some form of schooling, Table ED-1. Of those not currently attending school, 16% have completed less than a primary level education, 39% primary-level, 22% secondary-level, 14% sixth-form level and 3% university level, Table ED-2.
In Gardenia there are no education facilities. Primary School aged children from the village for the most part attend Biscayne Government School. However, a small number of parents who work in the Belize City area choose to have their children attend primary school there for matter of convenience and better quality. In addition and given the absence of secondary and tertiary level education services in the village, many youth commute on a daily basis to Ladyville/Belize City via public and private transport for educational services, (KII, 2017).

Health: Generally and outside of minor colds and occasional treatment for asthma, the residents of Gardenia appear in overall good health; additionally, no major outbreaks associated with dengue, malaria or cholera was reported (KII, 2017).
While residents across the Village appear in general good health, a number of residents report, being affected by the presence of chronic illnesses (non-communicable diseases) primarily among the older population and to a lesser extent mature adults. Principal among these NCD are: diabetes (3%), hypertension (7%), asthma (7%), arthritis/rheumatism (20%), kidney disease (2%) and glaucoma (2%), Table H-1.

With respect to disabilities, an estimated 3% prevalence rate is detected as measured by the severity scale adopted from the Washington Group on Disability Statistics, i.e. 3% of Gardenia residents are reporting 'lots of difficulty/cannot do at all' as it relates to seeing, hearing, walking/climbing stairs and/or communicating/speaking, Table H-2. For a breakdown of specific disability type, see Tables H-3 – H-7.

In Gardenia, 97% of the residents report having heard of AIDS, Table H-8. However, only 29% have 'comprehensive correct knowledge about HIV prevention', i.e. the proportion of respondents who 'knew of two ways of HIV prevention' AND 'knew that a healthy looking person can have the AIDS virus' AND 'rejected the two most common misconceptions', Table H-9. In addition, only 41% could correctly identify the three ways of mother-to-child transmission of HIV, Table H-10.

Gardenia has no resident health staff/facility; as a result villagers must seek medical services in Belize City, (KII, 2017).

Dwelling Occupancy and Type: Eighty-eight per cent of Gardenia residents own their home in which they live and the land it is located on with the remainder renting, Table DW-1. Dwelling type is predominantly, undivided private houses, 91%; with the remaining 9% being part of a private house, Table DW-2.

Crime: Seventeen per cent (17%) of residents report having been a victim of crime in the past year preceding the Baseline Survey, Table CR-1. Among the leading types of crime to which they are reportedly victims, include: manslaughter/murder (50%) and sexual assault (50%), Table CR-2.

Unemployment and Category of Workers:

Persons in employment comprise all residents above the age of 14 years who during the week prior to the Survey were either in paid or self-employment. The sample estimates for the economically active population in Gardenia stood at 51 persons with 3 either actively seeking work/did not want to work, Table E-1. To this end, the unemployment rate for Gardenia was estimated at 5.9%. The distribution of workers' categories includes self-employed (24%), paid employee-government (16%), paid employee-private sector/NGO (36%), paid employees-INGO/Embassy (10%), and unpaid family workers (10%). The remaining proportion did not wish to state their category Table E-2.

Poverty Distribution: In 2012, the Statistical Institute of Belize produced a national poverty map using 2011 data from the MICS and based on the small areas estimation (SAE) technique. As summarized in Table 5.6, Gardenia is characterized as a Village with middle socio-economic status. The relative socio-economic standing of this Village against the national (221 communities) and district (34 communities) rankings are 61st and 18th respectively, i.e. the 18th 'wealthiest' community in the Belize District and 61st in the country overall (SIB, 2012).

Table 5.6: SES Ranking Gardenia.

Road Section (RS)	District	Wealth Index Quintiles	Wealth Index Score	SES Ranking	
				National	District
RS-II	**Gardenia**	**3**	**0.0652**	**61**	**18**

5.6 Findings: Biscayne Village

Administratively in the Belize District, Biscayne Village as a population centre is located at mile 24.5 on the Phillip Goldson Highway. What follows is a summary baseline profile of the Village as it relates to:

- Population Size and Structure,

- Demographics,
- Governance, Social Cohesion and Community,
- Public Utilities,
- ICT,
- Education,
- Health,
- Land and Dwelling Occupancy,
- Crime,
- Unemployment and Workers' Category,
- Poverty Distribution.

Population Size, Growth, and Structure: The 2010 population Census recorded a population count of 517 residents and 130 households. The male population outnumbered that of the females with a male:female sex ratio of 1.13. The average annual intercensal population growth for Biscayne is estimated at 4.1% above the estimated 3% national rate. This places the 2016 estimated population at around 530 residents and 133 households (BET, 2017).

Biscayne's population structure is best characterized as an "expansive population pyramid" with an increasing pre-reproductive population age cohort (0-14 years). Of importance to note is that a number of age cohorts are notably missing in the post-reproductive groupings (60+). This perhaps is as a consequence of Biscayne being a fairly young community parlayed with the effects of emigration. The current sex ratio is estimated at 0.67 suggesting a marked decrease in the overall number of resident males relative to the 2010 Census. To this end, the number of females has outstripped the number of males and outnumbers them particularly in the pre-reproductive and reproductive age cohorts, Table D-1.

Demographics: Biscayne is predominantly a Creole community. Creoles are by far the major ethnic group, comprising 91% of the population followed by Mestizos at 5% and East Indian at 4%, Table D-2. English and Creole are the most widely spoken languages followed by Spanish to a lesser extent.

With respect to union status, 66% of residents are not in a union; when adjusted for the proportion of children in the Village, 46% being children, this leaves 20% of adults not in a union. A further 1% is in a visiting relationship, 19% in a common-law union and 12% are married and living with their spouse, Table D-4.

Governance, Social Cohesion and Community Life: Subject to the provisions of the Village Council Act Chapter 88 of the laws of Belize, Biscayne, like other established villages, has a duly elected 7-member Council, a female chairperson and 4 female and 2 male councillors serving the residents for the period 2016-2019. The Council reports a good working relationship and cooperation with the Area Representative for the Belize Rural North electoral constituency (FGD, 2017).

As is customary in community life in Belize, politics and religion permeate all levels of society and walks of life. Biscayne is no exception as the Village now finds itself polarized across political lines with the political currents being more overt and charged, especially leading up to village council and national elections. Notwithstanding this political polarization, the residents of Biscayne enjoy much leisure time. Outside of the school playgrounds and sporting facility the Village does not boast much in terms of sporting infrastructure. The social infrastructure in the Village is very thin and leaves much room for development (KII, 2017).

Public Utilities and Sanitation: The vast majority of households in Biscayne, 83% rely on the national grid managed by BEL for their electricity needs; the remaining 17% resort to other sources, inter alia lamps, candles and solar, Table U-1.

Likewise, most households, 93%, rely on BWS for general household water usage; the remaining proportion make use of rain water (4%) and rivers/streams (3%). In contrast, bottled water remains the primary source of drinking at 80% followed by rainwater at 14% and BWS piped water at 6%, Table U-3.
To this end and given that water lines and electricity poles are located within the road reserves as is customary, careful planning and notification to community residents and business establishments will be required to minimize disruptions and prepare for planned outages.

In Biscayne, 73% of households make use of flush toilets to septic tanks and the remainder some variation of pit latrines, Table U-4.

Households in Biscayne for the most part use their garbage as filling, while others resort to burning, illegal dumping, and/or burying since no public/private sanitation services are available to residents (FGD, 2017)

ICT: In Biscayne, 86% of residents report cell phone ownership, Table ICT-1. DigiCell as a service provider outnumbers their competitor, SMART, by a factor of 13, Table ICT-2. Sixty-five per cent (65%) of residents indicate satisfaction with their service provider as measured by the quality of service (good/very good) and full reception (talk/text/data) Table ICT-3.

With respect to internet access, 77% of residents indicate having access, 80% of which access the internet directly from their homes while others do so from friends/family/work/internet cafes, Table ICT 5 and Table ICT-6.

Education: In Biscayne, 33% of the residents are currently attending some form of schooling, Table ED-1. Of those not currently attending school, 20% have completed less than a primary level education, 21% primary-level, 39% secondary-level, 2% VOTECH, 5% sixth-form level and 3% university level, Table ED-2.

In terms of education infrastructure, Biscayne is home to one government managed primary school. A small number of parents who work in the Belize City area choose to have their children attend primary school there for matters of convenience and better quality. In addition and given the absence of secondary and tertiary level education services in the Village, many youth commute on a daily basis to Ladyville/Belize City via public and private transport for educational services (KII, 2017).

Health: Generally and outside of minor colds and occasional treatment for asthma, the residents of Biscayne appear in overall good health; additionally, no major outbreaks associated with dengue, malaria or cholera was reported (KII, 2017).

While residents across the Village appear in general good health, a number of residents report, being affected by the presence of chronic illnesses (non-communicable diseases) primarily among the older population and to a lesser extent mature adults. Principal among these NCD are: diabetes (3%), hypertension (3%), asthma (11%), and glaucoma (2%), Table H-1.

With respect to disabilities, an estimated 2% prevalence rate is detected as measured by the severity scale adopted from the Washington Group on Disability Statistics, i.e. 2% of Biscayne residents are reporting 'lots of difficulty/cannot do at all' as it relates to seeing, hearing, walking/climbing stairs and/or communicating/speaking, Table H-2. For a breakdown of specific disability type, see Tables H-3 – H-7.

In Biscayne, 95% of the residents report having heard of AIDS, Table H-8. However, only 44% have 'comprehensive correct knowledge about HIV prevention', i.e. the proportion of respondents who 'knew of two ways of HIV prevention' AND 'knew that a healthy looking person can have the AIDS virus' AND 'rejected the two most common misconceptions', Table H-9. In addition, only 42% could correctly identify the three ways of mother-to-child transmission of HIV, Table H-10.
Biscayne has no resident health staff/facility; as a result villagers must seek medical services in either Belize City and/or Orange Walk Town (KII, 2017).

Dwelling Occupancy and Type: Ninety per cent of Biscayne's residents own their home in which they live and the land it is located on with the remainder renting, Table DW-1. Dwelling type is predominantly, undivided private houses, 84%; with the remaining 16% being combined business/dwelling/part of a private house, Table DW-2.

Crime: Fourteen (14%) of residents report having been a victim of crime in the past year preceding the Survey, Table CR-1. Among the leading types of crime reported, include: sexual assault (33%), shooting (33%) and robbery (33%), Table CR-2.

Unemployment and Category of Workers:

Persons in employment comprise all residents above the age of 14 years who during the week prior to the Survey were either in paid or self-employment. The sample estimates for the economically active population in Biscayne stood at 40 persons with 2 either actively seeking work/did not want to work, Table E-1. To this end, the unemployment rate for Biscayne was estimated at 5%. The distribution of workers' categories includes self-employed (38%), paid employee-government (21%), paid employee-private sector/NGO (36%), paid employee-INGO/embassy (3%) and unpaid family workers (2%). The remaining proportion did not wish to state their category Table E-2.

Poverty Distribution: In 2012, the Statistical Institute of Belize produced a national poverty map using 2011 data from the MICS and based on the small areas estimation (SAE) technique. As summarized in Table 5.7, Biscayne is characterized as a Village with middle socio-economic status. The relative socio-economic standing of this Village against the national (221 communities) and district (34 communities) rankings are 63rd and 20th respectively, i.e. the 20th 'wealthiest' community in the Belize District and 63rd in the country overall (SIB, 2012).

Table 5.7: SES Ranking Biscayne.

Road Section (RS)	District	Wealth Index Quintiles	Wealth Index Score	SES Ranking	
				National	District
RS-II	**Biscayne**	**3**	**0.0515**	**63**	**20**

5.7 Involuntary Resettlement

This section is in tandem with the specified objectives of the World Bank Policy on Involuntary Resettlement, Operational Policy 4.12, i.e. to avoid or minimize involuntary resettlement; to make any resettlement activities a sustainable development program, including through project benefit-sharing and meaningful consultation of affected persons; and to assist displaced persons in their efforts to improve, or at least restore, livelihoods and living standards (WB, 2001). The

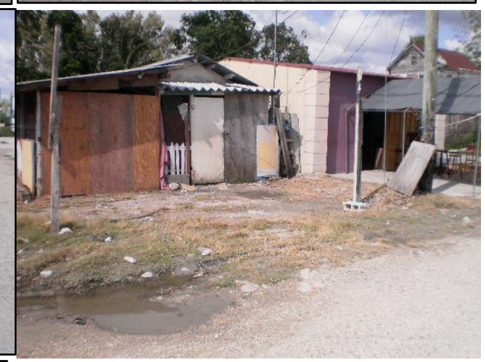
Policy extends assistance to people who do not own property but are nonetheless affected by development projects, including groups with communal and/or traditional tenure arrangements, renters, wage-earners and those without legally recognized rights to land and property that they occupy or use.

Discussion between the BET Team and the pre-feasibility Consulting Team is on-going. To date, the impact of land expropriation and resettlement tasks have not yet been identified. Once identified, and if necessary as triggered by OP 4.12, a Resettlement Action Plan shall be prepared which would seek to reduce the amount of resulting land expropriation and resettlement related to the proposed road rehabilitation project and ensuring reasonable compensation and assistance be provided to the population affected by construction works, so that their original production capacity, income level and living standard can be maintained or improved upon.

To this end, "Population affected by the project" herein refers to: (a) Population with all or part of its land permanently or temporarily affected by project construction; (b) Population with all or part of its houses permanently or temporarily affected by project construction; (c) Population with all or part of its production or business activities permanently or temporarily affected by project construction; (d) Population with all or part of its other land attachments affected by project construction.

Table 5.8 outlines, at least in preliminary form, persons potentially affected by the proposed road project; however as noted, any impact of land expropriation and resettlement tasks have not yet been concretely identified and are the subject of further discussions. However, once identified and as triggered by OP 4.12, a RAP shall be prepared.

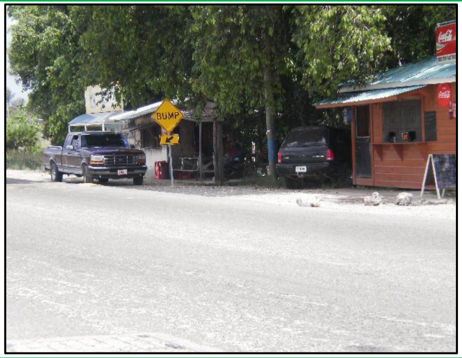
Table 5.8: Preliminary Identification of Affected Population (Impact of land expropriation and resettlement).

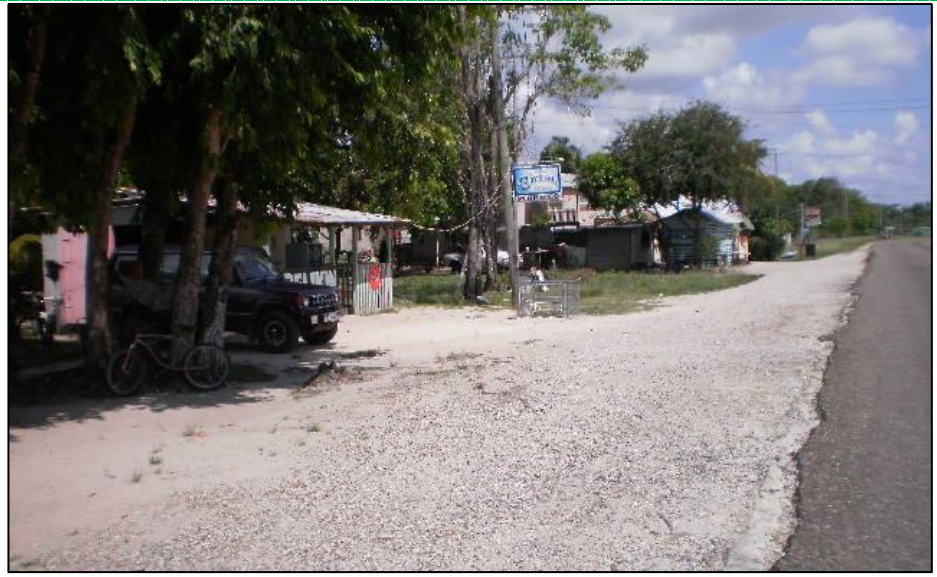
Road Section	Village	Description of Area	Graphic
I	Ladyville	5 makeshift structures at approximately mile 8 ¾ just opposite the Blue's Night Club on the LHS of the ROW travelling in a north-westerly direction. 4 vendors (furniture repair, barber shop, fast food/bar, and fruit shop) and 1 dwelling structure may require relocation.	     

I	Ladyville	3 temporary fruit/vegetable/fish vendors located at approximately mile 9 on the LHS of the ROW travelling in a north-westerly direction just passing the Our Lady of the Way RC Primary School may require relocation.	 
I	Ladyville	6 makeshift structures located at approximately mile 9 on the LHS of the ROW travelling in a north-westerly direction, 100 yards after the 2nd speed hump. 4 local vendors [Kloej's Kitchen, Perez Tamales Shop, Tire repair, Mechanic, J&L Restaurant, A&J Outlet (DVDs-CDs)] and 2 Congested area; compounded by derelict vehicles.	   

			 
I	Ladyville	Combined dwelling and business, tire repair shop and newly constructed unpainted concrete structure, at the intersection of the PGH and the entrance road to the Ladyville Technical High School (LTHS). Structure extremely close to the road reserve and causes obstruction to clear line of sight for vehicles exiting the LTHS service road and vehicles approaching from the south-easterly direction. Compounded given the need for buses to disembark students/teachers at the intersection and the vehicles/heavy equipment on the opposite side of the road associated with the construction company.	 

I		Five (5) makeshift structures, along the ROW at the intersection of the PGH and the Lord's Bank roadway. 3 on the RHS and 2 on the LHS travelling in a north-westerly direction. 5 vendors: tacos, fruits/vegetables, food/snack shop, Rotisserie/tacos, clothes. Fairly busy intersection by local standards and a designated bus stop. Compounded by the two Chinese stores with inadequate parking space/arrangements and the gas station in the same general area. Intersection requires re-engineering and any widening of the carriage way will require relocation of makeshift structures/vendors as well as requiring the Chinese businesses to make proper arrangements for customer parking.	     

I	Ladyville	Makeshift structure on the RHS of the ROW travelling in a north-westerly direction just passing the Evangelical Primary School. Will require relocation; livelihood affected during construction and operation phase	
II	Sandhill	2 makeshift structures and an abandoned police booth, located on the RHS of the ROW travelling in a north-westerly direction just passing the Boom junction. 2 food/snack vendors will need to be relocated; livelihood affected.	 
II	Sandhill	Makeshift structure located just in front of the NEMO Office on the RHS of the ROW travelling in a north-westerly direction. Structured used for BBQ/food sale on weekends; vendor/structure will need to be relocated. Livelihood affected.	

II	Sandhill	Bar, Stop & Go, located on the LHS of the ROW travelling in a north-westerly direction just passing the Maxboro community entrance, diagonally opposite. Establishment located in extreme close proximity to existing carriage way with little room for clients to safely park vehicles. Poses road safety concerns, particularly at night when combined with alcohol consumption and a poorly lit road. Any road widening may require relocation of existing structure.	
II	Sandhill	Makeshift structure, food vendor and small grocery shop (Cherry's Good Food, located at approximately mile 15 ½ on the LHS of the ROW travelling in a north-westerly direction. Road widening may require relocation; notwithstanding, livelihood would be affected during the construction phase.	

II	Sandhill	Wine vendor on the RHS of the ROW travelling in a north-westerly direction diagonally opposite the Pancotto RC Primary School. Road widening may necessitate temporary relocation; in addition, dwelling structure appears to be located in the road reserve and may require relocation. Dwelling structure and livelihood affected during construction phase.	 
II	Sandhill	Small yellow wooden dwelling structure located on the LHS travelling in a north-westerly direction at approximately mile 18 ¾ just in front of the SDA church. May require relocation given road widening and seemingly lies in the road reserve	

II	Sandhill	Vendor and makeshift structure (blue shop) and Sandhill Art Center located at approximately mile 19 ¼ approaching and just passing the speed bump after the Maskall Road junction travelling in a north-westerly direction along the ROW. Any road widening will necessitate relocation of vendors/Art Center;	 
II	Sandhill	Dangerous curves at miles, 16, 17 and 18 may require re-engineering inclusive of horizontal alignment. Any such horizontal alignment may require permanent land take, even if minimal.	
II	Biscayne and Gardenia	No immediately identifiable structures requiring relocation.	
I & II	Ladyville, Sandhill, Biscayne, Gardenia	BWS water lines, BEL poles and BTL underground cables are all located in the road reserve; additionally village bus stops will require demolition and reconstruction with appropriate bus lay-bys.	

5.8 Level of Support, Concerns and Recommendations

Seventy-five per cent (75%) of all residents across the Study Area have expressed high/very-high levels of support for the proposed road rehabilitation project and a further 17% remained neutral as they reportedly were somewhat sceptical that the road rehabilitation would actually materialize given prior promises of road/general infrastructure upgrade, Table R-1. Notwithstanding, the broad level of support, a number of issues/concerns and recommendations were also noted as summarized below.

Overall condition of the mile 8.5-24.5 segment of the PGH roadway was rated as poor/very-poor by 47% of the residents across the Study Area, Table R-2. Only one in every five resident gave a rating of good/very-good condition with a significant proportion, 32%, remaining neutral, Table R-2. During the rainy season, the road condition seemingly worsens with 59% of residents indicating poor/very poor compared to 34% during the dry season, Table R-3 and Table R-4. Furthermore, only 18% of residents rated their experience travelling the PGH by vehicle as being comfortable/very-comfortable; while a mere 5% rated their experience as a pedestrian as being safe/very-safe.

Overall, residents indicated that the three most important road features to them for the PGH are: better lighting, enforcement of speed limits and installation/maintenance of pedestrian crossings/speed humps, Table R-20 - R-22. At the time of the Survey, 10% of residents reported having personally been involved in/family member involved in an RTA on the PGH, Table R-26. “Too narrow/should be widened”, “people drive too fast/speeding”, “no/poor lighting and “driving under the influence” were among the top ranked problems associated with the PGH road section, Table R-17 – R-19. Additionally, the dust from the existing road was identified by 61% of residents as the cause of ‘problems’ and 18% indicated that the dust caused health related issues for them, Table R-10 – R-11.

With respect to mode of transport, use of public transport (56%) and personal vehicles (36%) ranked highest, Table R-12 – R-13. From the Survey it was apparent that the PGH forms a critical link for residents in the pursuit of their livelihoods and in accessing basic services. “Better access to services”, “faster travelling time”, and “safer roads for users” were among the top ranked benefits of the proposed rehabilitated PGH, Table R-23 – R-25.

5.9 Cultural Heritage

5.9.1 Archaeological Assessment: Introduction

In accordance with the National Institute of Culture and History Act Chapter 331, Revised Edition 2003, the purpose of the Archaeological study was to provide an inventory of archaeological sites along the route corridor, to identify any visible features of archaeological significance (both historic and prehistoric) that could be affected by the proposed rehabilitation of the highway, and to make provisions and recommendations for the protection or mitigation of any such features that would be impacted by planned road construction. The short time in which the study was conducted did not inhibit the quality of the study because both authors have considerable research experience and knowledge of the road corridor where they have been conducting archaeological investigations since the mid-1980's. Additional data for the region is also available in published reports by several archaeologists who worked in the region since the 1960's (e.g. Finamore 1994; Hester and Kelly 1980a, 1980b; MacNeish et al. 1980, 1982; Mock; Pendergast; Taylor 1980).

5.9.2 Review of Archaeological Data

In Belize, archaeological sites generally fall under one of three designated types: Preceramic, Prehistoric Maya, and Historic period settlements.

1. Preceramic sites are subdivided into two categories, Paleo-Indian and Archaic. The former includes the camp sites of the first human inhabitants of Belize and dates between 12,000 to 7,000 B.C. The subsequent Archaic phase spans the period from 7,000 to 1,200 B.C. Both phases pertain to occupants who culturally are considered Preceramic peoples or pre-Maya inhabitants.

2. Prehistoric Maya occupation extends from at least 1200 B.C. to the time when contact with the first Europeans was made around 1500 A.D.

3. The Historic Period spans from 1500 to 1900 A.D. and encompasses the time from Spanish contact to the early phase of British colonial settlement.

Human occupation of the East-Central Belize sub-region spans nearly 12000 years. The earliest evidence of occupation dates as far back as 10,000 t0 2,000 B.C. These early pioneers include nomadic, hunter-gathering groups of Paleo-Indians and Archaic people (Lohse et al. 2006). During the next 4,000 years, these early nomads were succeeded by Preclassic and Classic Maya civilization, Spanish missionaries attempting to convert the Maya to Catholocism, British and African settlers, and even American loyalists who immigrated to Belize following the American Civil War (Awe and Helmke 2015; Graham 2011; Graham et al. 1989; Helmke and Awe 2012; Mock 1997; Thompson 1972; Willey et al. 1965). Archaeological sites of these various cultures that have been identified in East-Central Belize range from lithic quarries and temporary camps, to large Maya settlements and 16th to 18th Century Colonial Period villages.

Evidence for occupation between 10,000 and 2500 B.C. was first identified by archaeologists from the University of Texas during surveys in the Sand Hill area (Awe and Lohse 2007; Hester et al. 1980a,b; Kelly 1993). Their preliminary investigations recovered Preceramic (i.e. Paleo-Indian and Archaic) stone artefacts within the vicinity of the Sand Hill community at two locations: the Lowe Ranch site and the Sand Hill Site (Hester, Shafer and Kelly 1980a; 1980b; Taylor 1980). The stone tools recovered included a Paleo-Indian projectile point from Lowe Ranch, and several Archaic period Lowe and Sawmill points (Kelly 1993).

A subsequent survey by the Belize Archaic Archaeological Reconnaissance Project (BAAR), conducted during the early 1980s and under the direction of Richard “Scotty” MacNeish, recorded several Archaic, sites in the ‘marshy savannah area’ north of the Belize River and east of Mexico Creek. The two sites mentioned above were further investigated and found to have stratigraphic occupation from that dated between 4000 to 2000 B.C. The BAAR Project also identified several other sites around the village of Sand Hill. Five of the sites were located in pastureland, while one was located in a modern road quarry in Sand Hill. The sites are situated on a slight sandy rise with occasional oak clusters and pines. Some are near water holes, and some are around chert (a.k.a. flint) quarries. Further to the south in the Ladyville area, BAAR archaeologists located another four (4) Archaic sites. While some artefacts were collected from the surface and in the humic layer, information also lay buried under as much as 60 cm of stratified matrix (MacNeish et al 1980; 1982).

There are numerous Ancient Maya sites in the area along the road corridor; including Altun Ha located just over 15 km to the northeast of the Belize River and approximately 8 km east of the Philip Goldson Highway (Pendergast). Another large site, Chau Hiix, lies just south of the village of Crooked Tree (Anders 2005). Sites in closer proximity to the highway consist of smaller settlements that are represented by formal plazuela groups and scattered house mounds (Harrison-Buck et al. 2016; also see Harrison-Buck et al. Fig. 8). These include Jabonche, Saguro, Quiroez and Hines along Black Creek, the Jonesville site, which has several small house mounds; Kunahmul (aka New Boston), which is a settlement area consisting of a ceremonial centre, several house mounds, burials, and lithic workshops, located roughly 1km to the southeast of Jonesville; and the Salt Creek settlement area, located 7 to 8km to the northeast of Sand Hill. Further to the southeast is a settlement around Ladyville, also known as Hume Creek, consisting of several house mounds.

During the early 1990s, Boston University archaeologist Daniel Finamore (1994) conducted a survey along the lower Belize River to locate 18th century British/African wood cutter camps. Finamore's map of the eastern Belize River, which includes Mexico Creek, Jones Lagoon, and Black Creek to the north, and Mussel Creek to the South, notes several, late 18th century, wood-cutters property claims in the area. His research also noted that much of the area to the north, south, and west of the river contained numerous additional claims. He further reports that the survey along the Belize River was hindered due to the seasonal flooding of the river and that sediment deposition has buried many potential colonial period sites in this area. Many Colonial period sites are therefore not visible by surface survey, and only identified by extensive excavation (Finamore 1994).

The earliest site of English occupation along the road corridor, in what is referred to as the Bay Settlement, is Barcadares. This site was established around 1670 and abandoned around 1720. The best documentation of the site is that by merchant Captain Nathaniel Uring and published in a narrative of his voyages in 1726. Today, the small village of Grace Bank occupies the location of this early settlement. Artefacts retrieved during excavations here included 18th century ceramics, glass, and metal. These artefacts were recovered from the buried dark brown silty clay layers, 10 to 15 centimetres (cm) below the surface.

A later settlement, called Convention Town, was occupied most intensively during the 1790s, probably as a result of the evacuation of the Mosquito Shore in 1787. Reference to this settlement come from court records dating to early 1791 (Finamore 1994). A census of this settlement, conducted in 1790, indicated that nearly 500 people were living here. It is thought that Convention Town may have been the location for earlier occupations by wood-cutters in the early 1700s, or American loyalists in the later 1770s. It also appears to have been occupied during the later part of the 1800s and early 1900s. The last occupation of this site consisted of a small hamlet of Creole families during the middle of the 20th century. Most artefacts retrieved from this site were recovered from depths of 5 to 15 cm (Finamore 1994).

Other Historic sites located in the area, or in similar locals, include Mackenzie Run, located at the mouth of Black Creek along the Belize River; Little Fall, consisting of Historic bottles and pot sherds; and Burrell Boom where historic bottles, the remains of an anchor and an old boom chain were recovered, in addition to a historic cemetery.

As indicated by the review of previous research along the Philip Goldson Highway, there are many Preceramic and Colonial period sites located near the road corridor, but because of flooding and other disturbances, surface identification is often difficult or impossible. Other sites, particularly those pertaining to Maya civilization, are more noticeable because they consist of either architectural remains, or artefact scatters on the ground surface. This information and situation was carefully considered while the conducted this survey.

Figure 5.1 shows a Map of Belize and Selected Archaeological Sites and Figure 5.2 shows Major Archaeological Sites in North Central Belize. (After Buck-Harrison 2016).

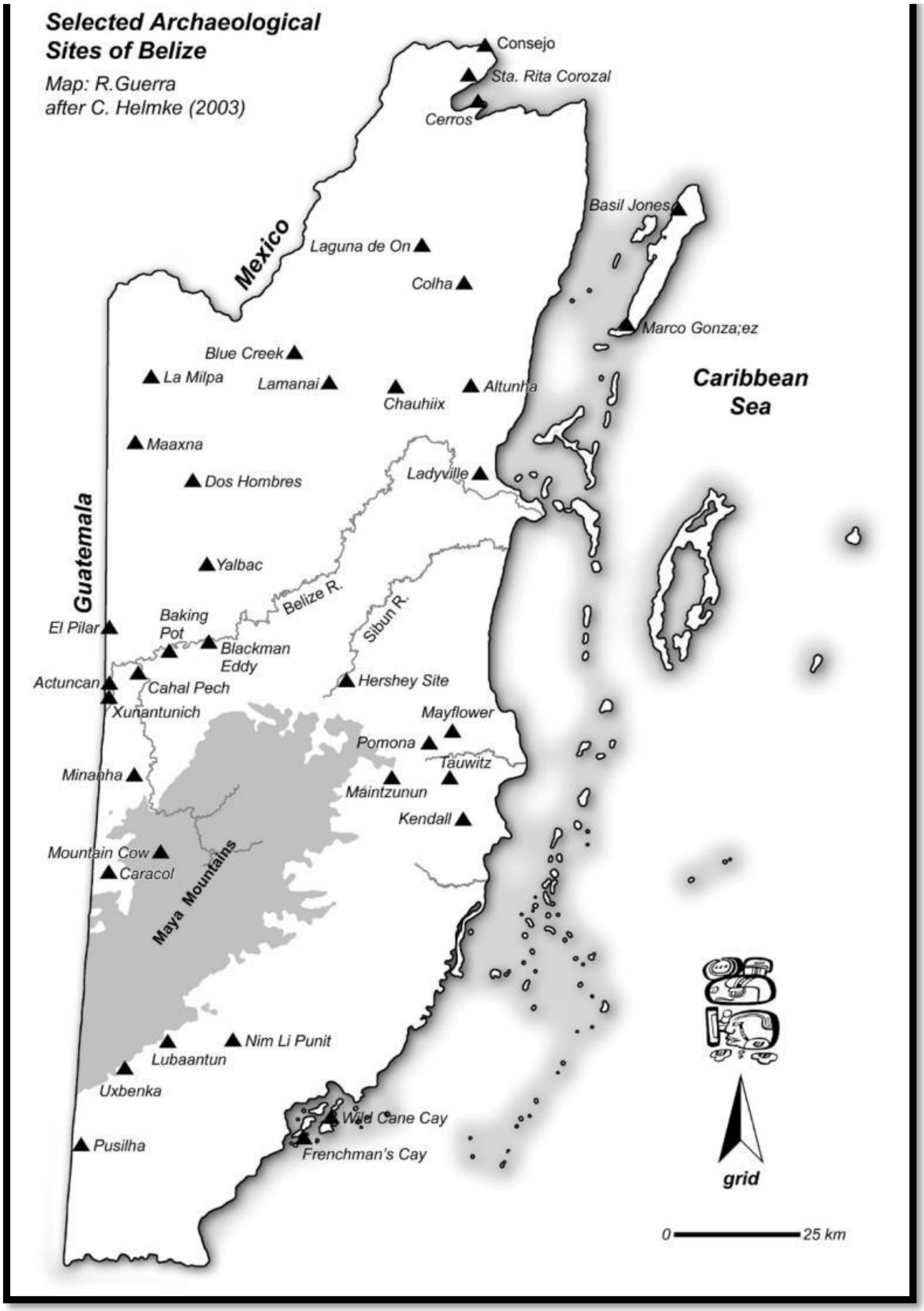


Figure 5.1: Map of Belize and Selected Archaeological Sites.

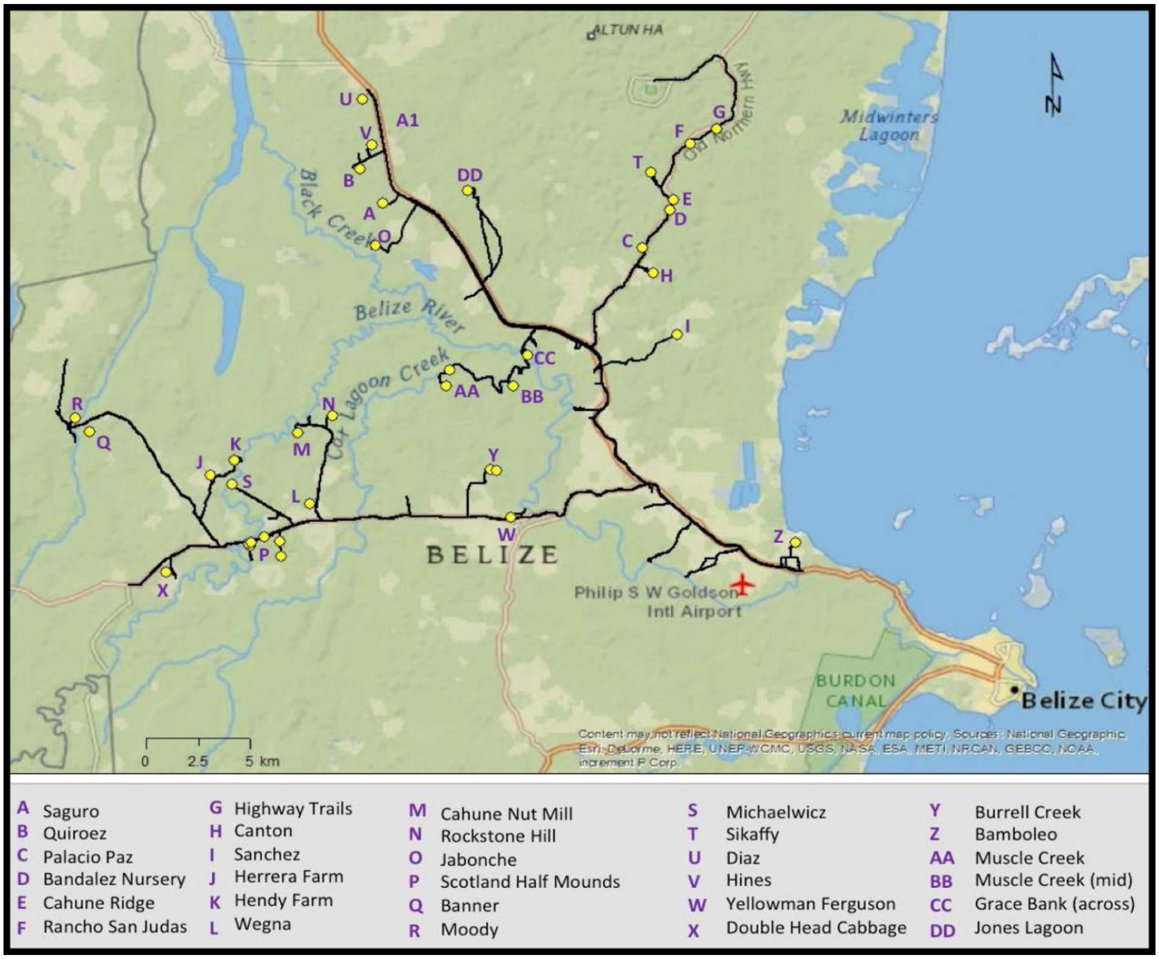


Figure 5.2: Major Archaeological Sites in North Central Belize. (After Buck-Harrison 2016).

5.9.3 Field Survey and Research Methodology

For the purpose of this report, the road assessment was considered as a single corridor. The proposed development corridor was categorized as (1) Direct impact zone being the right of way of 9.15 m (30 ft) and (2) the secondary impact zone being a 18.3 m (60 ft) access corridor. Each of these impact zones was measured from the centre of the existing road, i.e. 4.575 meters were measured from the centre of the road on both sides to accomplish the desired 9 m (30 ft) right of way (Figure 5.3).

The archaeological assessment requested by the BET was conducted in two stages. Areas along the existing road corridor were reconnoitred to identify archaeological features within a 9.15 m

(30 ft) access corridor on both sides of the road commencing at the centre point of the right of access. Potential quarries were investigated to identify a 45.72 m (150 ft) diameter where minimum disturbances to archaeological features would occur.

A total of 5 potential and existing quarry zones were identified by BET and the Geology Department (GOB) for the proposed road rehabilitation. Of these, 2 (two) quarries, Biscayne 1 and 2 were close to the road rehabilitation project and 1 (one) quarry, Rockstone Pond, was a short distance from the rehabilitation area. The other 2 (two) quarries, Bomba and Albion Island were a considerable distance from the proposed rehabilitation area.

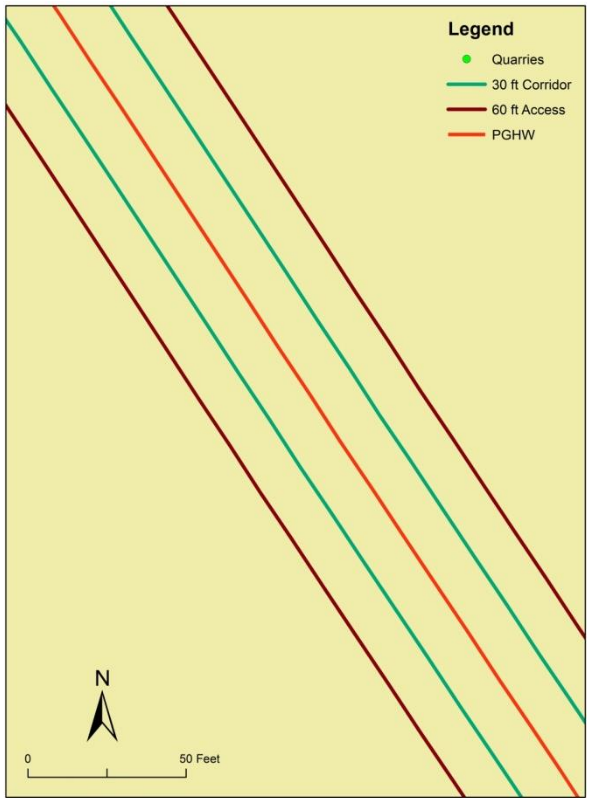


Figure 5.3: Road Corridors with Primary and Secondary Impact Zones.

5.9.4 Survey

The survey was conducted with a five (5) person crew over the course of four days. The archaeological survey served to assess the total extent of archaeological remains within the project area, focusing on locating and recording all visible structures, sites, and cultural features within the area that would be impacted by the road rehabilitation project. A description of the methodology and results of these investigations are provided below.

5.9.5 Methodology

Prior to field survey, maps of the region were examined in an effort to acquire information on the terrain and resources along the road corridor. This was subsequently followed by a review of reports of previous scientific investigations in the region, with particular emphasis on geological, biological, and especially archaeological research. Information from several of the maps that were acquired was later incorporated into a Geographical Information System Database that allowed analyses of the corridors. For the purpose of this survey, a Belize Water and Services upgrade water system ditch provided a glimpse of sub surface material to aid in identifying potential areas with archaeological materials that may be buried below surface.

5.9.6 Results of the Survey

During the walk over survey conducted in March 2017, the road corridor was reconnoitred in the primary impact zone and then in the secondary impact zone.

- ***Primary Impact Zone****:* There were no visible sites, structures, or features identified in this Zone.
- ***Secondary Impact Zone:*** The survey in this area utilized several ditches dug by BWSL and MOW for water system upgrade and road drainage to look for possible buried features. In this portion of the road corridor, there were no visible archaeological remains and no subsurface artefacts were identified in the ditches.
- ***Quarries:*** Due to the limited timeframe of this project, a full reconnaissance of all quarry sites was not possible. A brief inspection of the 3 potential quarries closest to the project area did not identify any archaeological material. However, project implementers must be cognizant of subsurface features especially around the Albion Island, Rockstone Pond, and Bomba areas. Since the review of previous research in these areas identified several archaeological sites, it is strongly recommend that any horizontal expansion of these existing quarries should only proceed after a more systematic survey of the area has been conducted, and prior to any mechanized material extraction.

5.9.7 Conclusion and Recommendations

Archaeological data collected by the survey, and by several archaeological projects in the past, serve to establish that there are various archaeological sites in the relative vicinity of the Philip Goldson Highway. These sites range in date from the Paleo-Indian and Archaic period, to early Colonial period settlement. It is important that developers recognize that Paleo-Indian and Archaic sites are difficult to detect, first because of the extreme age of the remains, and second because these people utilized campsites that leave limited evidence of their presence. The same is true of early Colonial Period settlements. As was noted above, the review of the archaeological literature indicates that others have found evidence of these sites along the corridor. In the case of sites pertaining to Maya civilization, at least two large sites, Altun Ha and Chau Hiix, are located near Rockstone Pond and Crooked Tree respectively. Other small sites and settlements are dispersed along the way, not too far from the highway. **Here again, although no evidence that these sites would be impacted by the rehabilitation of the highway, it is recommended that project implementers be mindful of their relative proximity to the road corridor.**

If there is a possibility that quarry areas will be mined along the existing roadway, then an archaeologist should also survey the area to determine if there are *in situ* archaeological materials or sites. If such materials are found, then such quarries should be eliminated from use as borrow pits, or the archaeological sites should be salvaged/mitigated prior to their removal.

5.10 Cemeteries and Other Cultural Heritage

All the communities have their respective cemeteries managed by the village councils; death and burial in these rural communities, Ladyville to a lesser extent as it is larger and more dispersed with high urban influences from Belize City, are very much an entire village affair as generally everyone knows one another. To this end residents are highly supportive during this period of grief and loss; normally all differences, including politics, are placed aside.

It is not anticipated that the road project would impact on any of the designated cemeteries. Additionally, the road project stands to impact on the existing Sandhill Village Art Center located approximately at mile 19 ¼ along the ROW and in the road reserve. The structure may require relocation and as such, temporary interruption to the usual activities would occur.

CHAPTER 6: ASSESSMENT OF ENVIRONMENTAL AND SOCIAL IMPACTS

6.1 Overview

This section of the Environmental Social Impact Assessment (ESIA) presents the assessment of the potential environmental and social impacts associated with the proposed road rehabilitation project. For each relevant environmental and social parameter, the potential impacts are discussed. The evaluation of potential environmental and social effects during the ESIA aims to be as accurate and objective as possible, whilst providing as much detail as is available according to the proposed design. Many of the potential impacts have also been taken into account during design of the project through iterative discussions with the design engineers and Ministry of Works (MOW). The ESIA is primarily concerned with the identification, assessment, and mitigation of significant environmental issues and thus an exhaustive list of all potential impacts is not presented here.

In this assessment, the proposed mitigation measures for addressing potentially adverse environmental and social effects are also presented. In some instances, there may be overlapping impacts and mitigation measures due to similar site-specific activities and conditions. As with all road works, the overarching impact is to improve the lives of the resident population, specifically those of the study area. With this in mind, the following provides an assessment of the impacts in accordance with the Terms of Reference.

6.2 General Impacts Associated with Rehabilitation of Philip Goldson Highway (Miles 8.5 to 24.5)

The designs of the road, bridge, culverts replacements and drainage improvements will be undertaken with full consideration of the requisite international American Association of State Highway and Transportation Officials (AASHTO) standards and the necessary environmental and social safeguards.

The Project area is divided into two sections, namely:

(i) Section 1: Vista del Mar junction at ¼ mile East of mile 8.5 to Burrell Boom Junction at mile 14, a length of 5.5 miles (8.8 kilometres);

(ii) Section 2: Burrell Boom Junction to mile 24.5, Philip Goldson Highway (PGH) 1.5 miles after Gardenia Village into Biscayne Village, a length of 10.5 miles (16.8 kilometres)

The rehabilitation of this stretch of road will require major earthworks by scarifying the existing road surface and shoulders. These works will allow for the improving of the final vertical alignments by adding new pavement material and blending with the scarified material. Sections of road pavements that are determined to be unsuitable will be removed and replaced with appropriate base course material. These construction activities will be carried out with minor disruption to the traffic.

The earthwork construction activities will also entail the replacement of existing culverts and the possible replacement of the Mexico Creek Bridge.

A typical cross section that could be considered for the proposed rehabilitation and which would be similar with the section of highway that is presently being completed between the Haulover Bridge and the Airport Road is provided in Figure 6.1. The consideration would allow the continuity of the highway as it relates to the cross section. The cross section provided was obtained from the Philip Goldson Highway (Northern Highway) Feasibility Study and Preparation of Detailed Design, Haulover Bridge to Airport Road, February 2014 and prepared by DIWI Germany GmbH (Work and Construction Firm) in association with Young's Engineering Consultancy Ltd. (Engineering Firm (Local)).

Key aspects to ensure the serviceability of the rehabilitation works of the road are the drainage works, the replacement/retrofitting of culverts and the replacement of the Mexico Creek Bridge. The activities to be carried out consist of land clearing, excavation, and disposal of unsuitable material and backfilling of imported material.

Golder reported 42 culverts while BET reported 36. When both lists were compared, Golder's list has eight culverts that are not in the BET's List and BET's List has two culverts that are not in the Golder's List. Verification by BET was conduct on July 5, 2017 and the findings are listed in Annex XIV. The possibility is that these culverts do exit but because of past highway refurbishing, these may have been covered and a visual inspection could not have detected them.

Of those identified by BET, twenty-five culverts will require replacement as a result of being undersized or structurally compromised (these include culverts identified after comparing the Golder's and BET's Lists at Lady of Our Way Primary School and culvert after Tubal School – Annex XV). Although thirteen culverts are not recommended for replacement, certain actions such as headwall construction and/or clearing of outfalls are required. In addition, it is recommended that a few additional balancing culverts be added to improve wetlands connectivity within section 2B. There is also the recommendation for the placement of additional culverts to be placed in Section 1 A (on the north side of Mr. John Estephan's Building) to align with existing drain. In addition, the two new culverts in front of Mr. Estephan's, building are recommended to be connected by the extension of the enclosed sidewalk/side drain draining laterally to the main drain.   A detailed breakdown of culverts location along both project sections and culvert size is provided for in Annex XV.

A typical cross-section of the proposed bridge at the Mexico Creek crossings is to be consistent with international standards and taking into account key environmental, social, and economic considerations. Based on the results of the preliminary design and specifically the vertical alignment a decision is to be made whether the Mexico Creek Bridge is to be replaced or not. Therefore, if the bridge is to be replaced, it is recommended that the new bridge be a single span bridge raised one and a half metres above the maximum flood level.

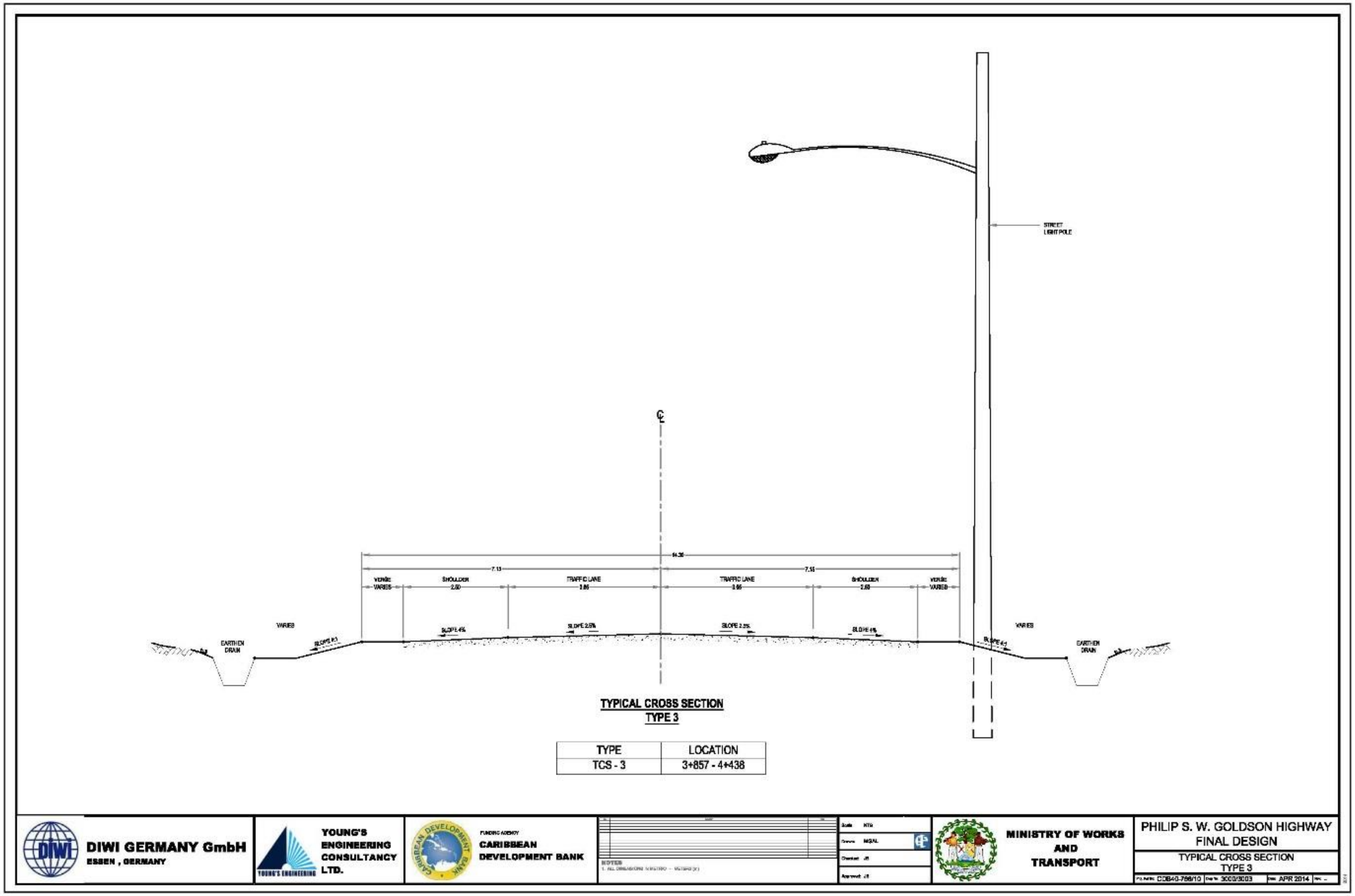


Figure 6.1: Typical Cross Section.

6.3 Impacts Related to Geology

6.3.1 Tectonics and Seismicity

The Corozal Basin exhibits a NNE-SSW trending fault system of normal faults that parallel the structural highs, this fault system is considered tectonically inactive. The study area has two splays of the transpressional faults (see Figure 6.2) that parallel the Shipstern Ridge (Purdy 2000) structural high. There was no evidence of any structural expressions of the faulting within the study area. Regionally the alignment of the lagoons in close proximity to the study area, namely Crooked Tree Lagoon, New River Lagoon, is fault oriented.

6.3.2 Geological Risks/Evaluation

The geological risks within the study area are minimal and subject to very site specific localities. These localities of concern are due to subsidence and differential settling due to the presence of the sands in the marsh setting with high organic content underlain by the impermeable clays that create a scenario of a state of semi-permanent inundation that allows for land subsidence and sinking. This is exhibited in the sections of the road primarily between Sand Hill and Biscayne where there are numerous dips in the road alignment due to partial subsidence of the road base. As the entire zone within these marsh areas has similar characteristic of low load bearing capabilities it allows for plastic deformation along the entire road carriageway creating a sinusoidal horizontal road alignment. This issue of subsidence needs to be evaluated and factored into the engineering design of the road upgrade.

The study area is in a tectonically inactive region although it has two splays of the NNE-SSW fault system within the study area; as it is inactive it has very little risk in terms of seismic impact. The low relief with an elevation difference of +/- 20m from the SE (Lords Bank junction) to NW (Crooked Tree junction) alignment of the road section reduces the risk or the potential of slumping or landslip.

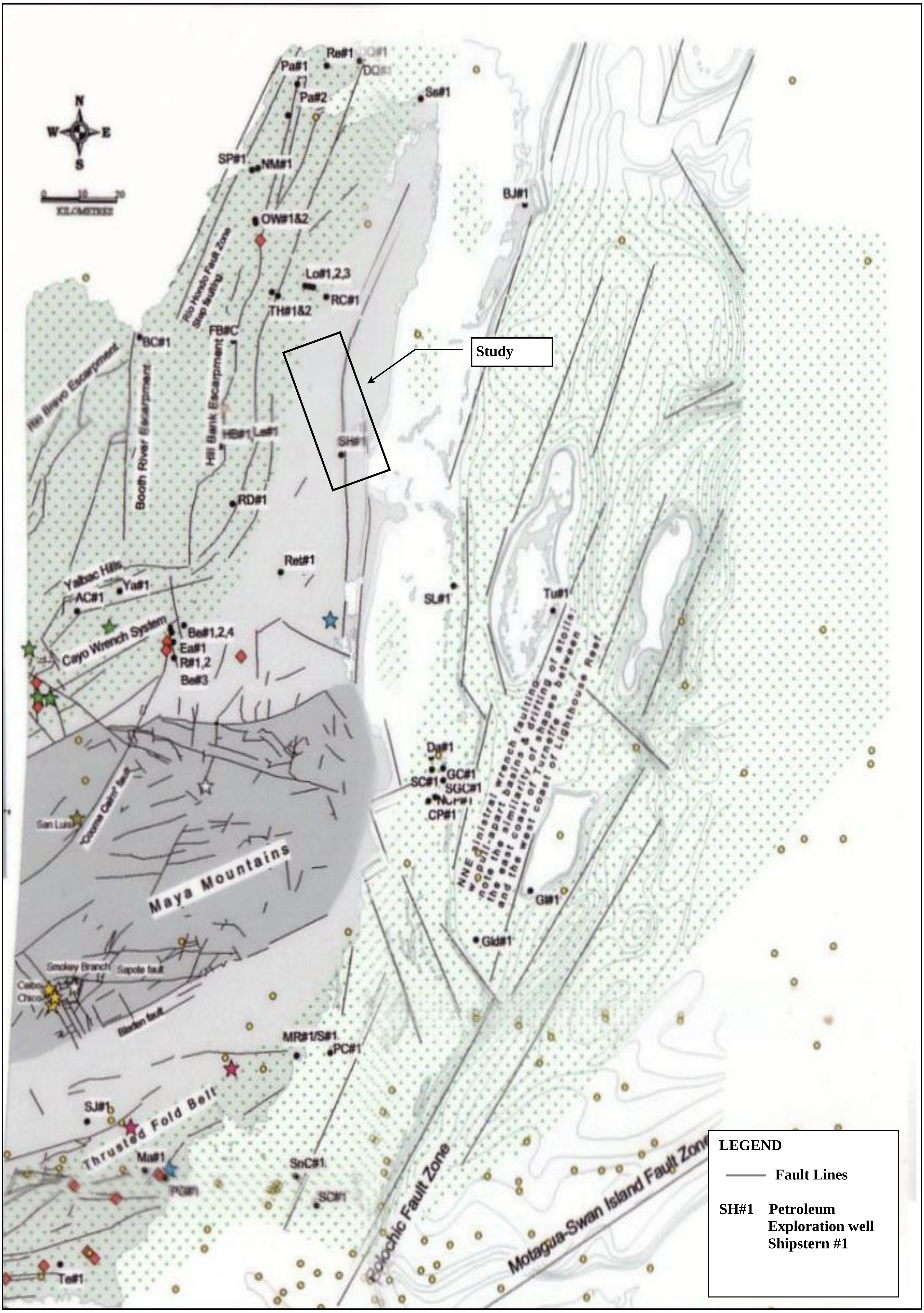


Figure 6.2: Tectonic Map of Belize, extracted from Cornec, 2010, Geology Map of Belize (after Purdy, 1975).
Note: Labels e.g. SH#1 represent petroleum exploration wells.

6.3.3 Material Requirements and Extraction

6.3.3.1 Site selection criteria

In selecting the sites for the potential supply of the required volumes of material for base, sub-base, and wear-course, a selection criteria was applied that each site had to meet in order to be eligible for consideration:

- **On-land extraction:** in an effort to reduce the negative impacts to water bodies and aquatic habitats, it was determined that no active river coarse extraction sites would be evaluated, with the exception of the evaluation of river operations for gravels that could be a potential source of wear coarse materials (chippings) in the event that no alternative source of wear coarse materials could be identified.
- **Reduced Footprint**: sites that have the ability to yield large volumes of material within a limited acreage, where possible hillocks with large lateral exposure relative to surrounding topography or areas that exhibit a relative topographic high in comparison to the surrounding areas.
- **Existing disturbed sites:** evaluation of existing or abandoned quarries that have the potential to provide the volumes required. This is done in order to prevent the additional scarring of undisturbed locations.
- **Proximity to water bodies:** identification of sites that have the potential of utilizing either a closed water system (for washing/screening) or that do not pose the threat of accelerated run off and sediment loading into existing water bodies.
- **Material Specifications:** meets minimal requirements for hardness, compaction rates, skid and wear resistance (wear course).
- **Use of native materials:** where possible or practical use of materials from within the same geological region, to prevent the introduction of non-native materials.
- **Proximity to roadway:** in order to reduce project cost and increase efficiency and efficacy, utilize extraction sites that are within the closest proximity, where possible. The factor of material availability versus material type versus material suitability is considered in the determination of reasonable haulage distance, in some instances a greater than normal haulage distance is accepted due to lack of available materials within the immediate project area.

- **New quarries:** examine only potential new quarries that can be placed away from roadway with a curved access road and maintain a minimum vegetated buffer of 500m

6.3.3.2 Identification of Sites

There were no previous studies of the project area on the existence of potential sites. MOW had done some preliminary works in the identification of quarry sites in the initial construction of the roadway, but currently material for maintenance is hauled from distances greater than 35km. BET undertook an extensive evaluation of the identified sites with an aim to identify sites for each phase of the road upgrade. Consideration was given to greater than normal haulage distance for only the specialized materials (chippings). The use of alternative fill materials that fall within the acceptable standards of MOW (clay fill, sand fill and clay and sand fill) was also given consideration due to close proximity to the project area.

6.3.3.3 Potential Sites Selected for Material Supply

Of the known quarries and potential quarries that were identified and examined to determine their material type, material abundance, material competence, and viability for use for each of the construction phases of the highway and their proximity to the highway, fifteen (15) quarry sites were selected with no new quarry being proposed. A 16th quarry was identified based on its material quality and immediate supply to meet demand but which did not meet the proximity criteria (Table 6.1 and Figure 6.3).

Due to the frequency and location of the quarries that yield similar type of material, they are grouped for the purposes of description. The following are the quarries selected:

- Six quarries that can provide clay, clay with chert or sand fill; all located within the Burrell Boom – Hattieville area (five are within the ***Proximity Criteria***), material that can possible be used for base (clays and clay with chert) and sub-base (sand fill) for raising elevation of the road carriage way.
- Four quarries that provide pine ridge sand (quartz sand), located in the Burrell Boom, Biscayne area, material that can be used for base and sub-base (may need stabilization) for raising elevation of the road carriageway.
- One limestone and marl quarry in the Rockstone Pond, Old Northern Highway, is material that can be used for base and sub-base.

Table 6.1: Selected quarries that met or exceeded the selection criteria for the Philip Goldson Highway upgrade.

BET SELECTED QUARRIES						
DATUM NAD 27 CENTRAL ZONE 16						
#	Eastings	Northings	Location	District	Remarks	Potential Material Use
1	350258	1934568	Boom-Hattieville area	Belize	Private Quarry, Ewing. Clay and Sand Fill	Base and Sub-Base
2	349205	1941165	Burrell Boom	Belize	Private Quarry, RODLA Construction Ltd. Clay and Sand Fill	Base and Sub-Base
3	350218	1933776	Boom-Hattieville area	Belize	Private Quarry, RODLA Construction Ltd. Clay and Sand Fill	Base and Sub-Base
4	354101	1944160	Boom-Hattieville area	Belize	Private Quarry, Bella Vista Development Co. Ltd. Clay and Sand Fill	Base and Sub-Base
5	351718	1939385	Boom-Hattieville area	Belize	Private Quarry, Gillett. Clay Fill and Pine Ridge Sand	Base and Sub-Base
6	354390	1944438	Burrell Boom	Belize	Private Quarry, Gillett. Clay and Chert boulders Fill	Base and Sub-Base
7	350682	1940139	Burrell Boom	Belize	Private Quarry, Gillett. Clay Fill and Pine Ridge Sand	Base and Sub-Base
8	351844	1940578	Burrell Boom	Belize	Private Quarry, Gillett. Clay Fill and Pine Ridge Sand	Base and Sub-Base
9	333482	1911506	Royal Point, Sibun	Belize	Private Quarry, RODLA Construction Ltd. On Land Sand and Gravel	Wear Coarse (Chipping)
10	351185	1933010	Boom-Hattieville area	Belize	Private Quarry, Malic. Clay and Sand Fill	Base and Sub-Base
11	347582	1955802	Biscayne Area	Belize	Private Quarry, A & E Trucking. Pine Ridge Sand	Base and Sub-Base
12	357142	1957288	Rockstone Pond	Belize	MOW quarry (abandoned). Limestone and Marl	Base and Sub-Base
13	293199	1907292	Spanish Lookout	Cayo	Private Quarry, Spanish Lookout Trust Corporation. On land Gravel	Wear Coarse (Chipping)
14	291094	1907102	Iguana Creek, Spanish Lookout	Cayo	Private Quarry, Excel Construction Ltd. On land Gravel	Wear Coarse (Chipping)
15	292056	1907451	Iguana Creek, Spanish Lookout	Cayo	Private Quarry, Stones Ltd. On land Gravel	Wear Coarse (Chipping)
16	346228	1922868	National Aggregates, Hattieville	Belize	Note: Although outside distance criteria, it is recognized for its quality material and supply.	Base and Sub-Base

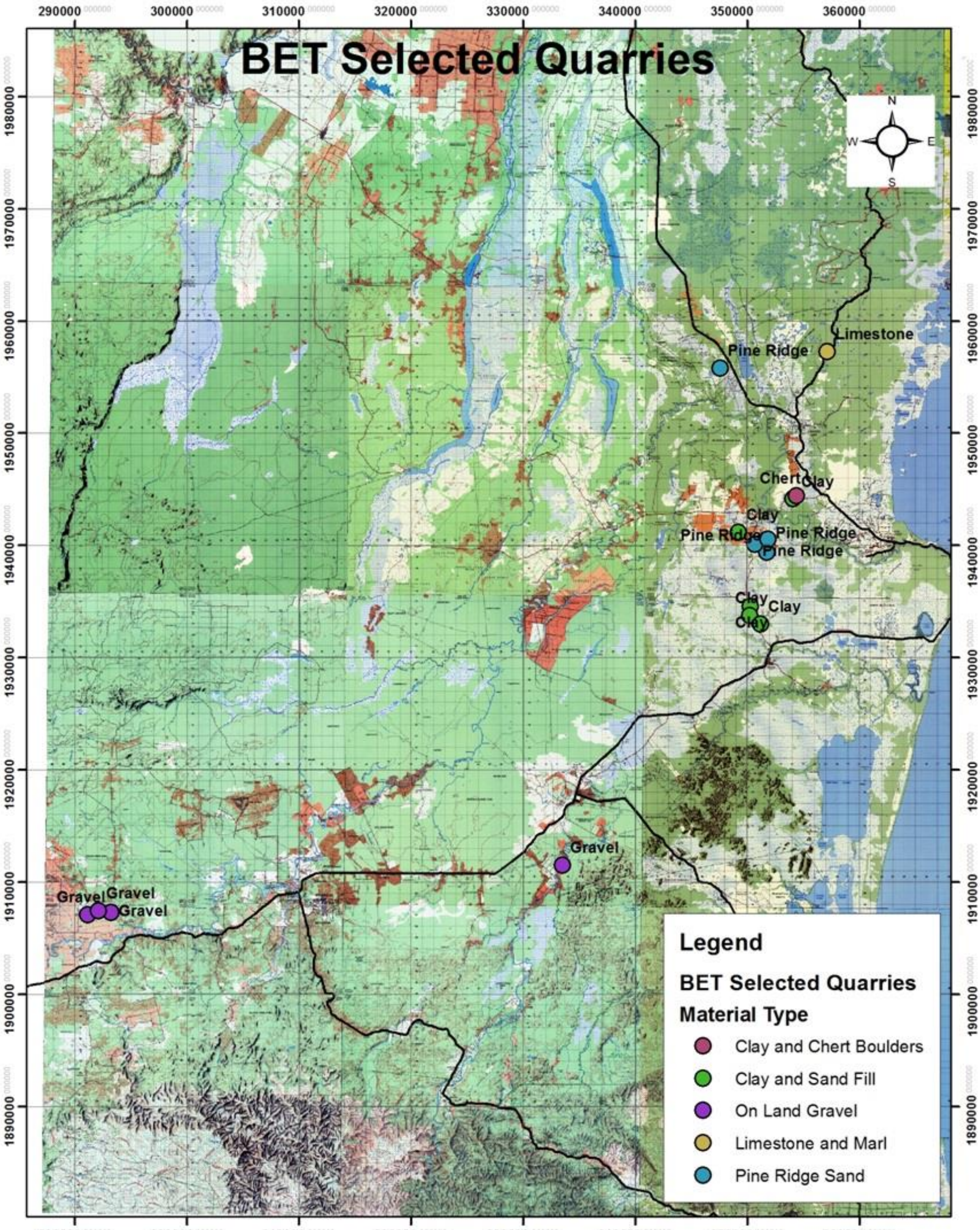


Figure 6.3: Fifteen (15) quarry sites were selected with no new quarry being proposed.

- Four on land gravel quarries: one located in the Royal Point area (sand and gravel) and the other three located in Spanish Lookout (chert), material to be used wear coarse (chippings).

Although marl can be obtained throughout most of the project area, through subsurface mining, as it is underlying the clays and sands, this option was eliminated as a potential for two reasons; it would require the opening of new quarries in order to satisfy the project needs as the three marl quarries within the project area have been abandoned and converted into ponds (Figure 6.4) and secondly the marls that are close to surface exhibit an extremely high percentage of clay, which eliminates it as meeting material specifications.

Figure 6.4: Converted abandoned MOW marl quarry Biscayne, Belize District.

For the provision of wear coarse materials the three quarries that conduct active river extraction for sand and gravel and gravel were eliminated (although the crushed river stone meets or exceeds material specifications for wear coarse) as this method of extraction is not encouraged due to potential impacts on water bodies and aquatic life.

The other limestone and marl quarries, although they meet or exceed the material requirements for the provision of base and sub-base, were eliminated due to overall haulage distance to the project area (increased project cost). Use of these quarries may be entertained in exigent circumstances or if an engineering requirement needs to be met to overcome a specific challenge in the road upgrade, (these circumstances would need to be site specific).

Clay, Clay with Chert and Sand Fill Quarries (base and sub-base)

Five quarries in the Burrell Boom- Hattieville area were identified that can yield materials that can be used for elevation uplift as base (clays, clays with chert) and sub-base (sand fill). These quarries are located in similar geological setting and are quarried in similar fashion (Figures 6.3 and 6.5).

- Sand fill is quartz sand with a high percentage of the red clays mixed in. The deposits typically extend 1 to 2 m deep after which the red to grey mottled clays are encountered.
- The clays are red to grey mottled clays that extend to depths, in some locations white to grey clay is also found (China Clay). The white clays are not suitable for use.
- In some locations, small iron rich nodules are seen interspersed in the clays.
- The clays with chert boulders locations have mixed in with the clays chert (quartz) cobbles and boulders of a sedimentary origin (free quartz) ranging in size from 15cm to

Figure 6.5: Typical clay, clay with chert and sand fill quarries.

- up to 0.5m, these chert boulders tend to be lenticular in shape and usually exhibit a calcareous outer layer. These are formed ***in situ*** within the clays.
- The method of extraction for both types of material is through the creation of ponds.

Pine Ridge Sand (quartz sand) Quarries (base and sub-base)

Four quarries for the provision of pine ridge sand (quartz sand), in the Burrell Boom, Biscayne area, material that can be used for base and sub-base, this material may need stabilization in order to be used for elevation uplift above a certain height (Figures 6.3 and 6.6).

- Pine ridge sand is a fine to medium-grained quartz sand derived from the erosion of the granitic bodies of the Maya Mountains and are transported and deposited in shallow lagoons. Because of this the depth of the deposits vary from 0.5 m to up to 1.5 m before grading into yellow to red sand "dirty sand" which is sand mixed with clays at depth.
- Areas are quarried through elevation reduction by scraping and levelling of the deposits so as not to include the "dirty sand".

Figure 6.6: Typical Pine ridge sand extraction and material.

On land Gravel Quarries (wear coarse and chip-seal)

The geology within the project area does not lend itself to yielding adequate material to be used for the wear coarse (chippings for chip seal) as such areas that are distant from the project area where evaluated. River extraction sites were eliminated due to the potential impacts to aquatic habits, four on land gravel sites were selected based on material type and suitability for use as a chip-seal (Figures 6.3 and 6.7).

1. **Rodla Construction Ltd.; Royal Point Sibun area, Belize District**
    - Extraction of on-land old river coarse, flood plain deposit.
    - Material is extracted from pits at a minimum distance of 100m from the river course, test pits vary in depth of up to 30m.
    - Large trees and areas prone to inundation are avoided.
    - The material is deposited in typical flood plain setting with a series of alternating gravels, sand and gravel, sand and topsoil beds varying in thickness from 1 m to 3 m. The beds show grading from coarse to fine. This allows for selective quarrying and separation of different material types.
    - Material is derived from the Maya Mountains, the headwaters of the Sibun River and are constituted of primarily igneous, metamorphic and meta-sediments.
    - Gravels are crushed to produce varying sizes of aggregates suitable for chip-seal.
    - The Ministry of Works and other private contractors in other road upgrade/maintenance projects currently using this material for chip seal.

Figure 6.7: On land extraction and material type, Royal Point Sibun area.

2. **Spanish Lookout on land Gravels, Cayo District**

- Three quarries in a general area with multiple locations have been identified for the supply of on land gravel (Figures 6.3 and 6.8).
- The lower areas of Spanish Lookout in the Iguana Creek area has been identified as the preferred site for the supply of wear coarse material for asphalt mix. This material type is quartz in the form of chert nodules with some agate ranging from cobble to boulder size, unconsolidated associated with a red to grey mottled clay.
- The deposits range in depth from 2 m to in excess of 12 m and can be quarried by simple scraping and removal, requiring screening and crushing.
- This material has been shown to have superior wear and skid resistance (Tunich Nah, 2004) in other applications and is currently being used by the Ministry of Works and other contractors in other road upgrade/maintenance projects for chip seal.

Figure 6.8: Typical on land extraction and deposits Spanish Lookout area.

Limestone and marl Quarry (base and sub-base)

Numerous limestone quarries were examined as the use of limestone and marl for elevation uplift is the preferred option as it provides the most stable base and sub-base without the need for stabilization, however most were eliminated because of distance from the project area. One abandoned quarry; Rockstone Pond, Old Northern Highway, Belize District, was identified and evaluated. The site is overgrown and would be required to be reopened to allow for active extraction, however the quarry in Bomba, Old Northern Highway, Belize District is used as analogue as it is the same geological unit and in the same geological setting (Figures 6.3 and 6.9).

- Tan to white marl with limestone boulders varying in size 10cm to 0.5m. inclusion of some chert boulders and cobbles
- Little to no clay content.
- Material can be scraped and ripped without the need for explosives,
- Due to the low vertical relief of the deposit, it is recommended that the material be removed through elevation lowering without going subsurface relative to the surrounding topography. This method does however require a larger footprint as it requires larger lateral extent.

Figure 6.9: Analogue quarry Bomba showing limestone and marl.

6.3.3.4 Road Cut/Road Realignments

Due to the low overall relief along the road section, +/- 20m vertical difference along the 25km section of roadway, it is not envisioned that any material can be obtained from road cuts or road realignments.

6.3.3.5 Mitigation Measures to Reduce Material Supply Impacts

The contractors will be required to employ Best Management Practices and engineering standards during earth moving operations. These will include careful soil stripping and storage, as well as site restoration that will ensure that the potential geological impacts are minimized. However, as most of the sites that have been identified are existing ongoing quarries that exist for commercial purposes beyond the scope of this project, some basic best practice techniques are being recommended for each material type/extraction methodology.

To reduce the impacts associated with materials supply, only sites that meet the set of pre-determined criteria will be utilized. Based on these criteria, several sites were eliminated due to associated environmental, archaeological, and geological impacts. To mitigate the impacts on any one specific selected site, the extracted volumes will be shared among the different sites to reduce the environmental impact footprint.

Clay, Clay with Chert and Sand Fill Quarries

The typical extraction methodology for these types of quarries is through the creation of "ponds" in the order of 10 to 15m deep, with each "pond" being abandoned when they breach the water table and an earthen berm is left to act as a water barricade between each extraction area. This method of extraction tends to leave isolated unconnected ponds with material sterilized and it also leads to areas of extraction having a larger footprint than required in order to yield the same volume of material. Figure 6.10 demonstrates the earthen barricade and the compartmentalization of the ponds with isolated materials.

Figure 6.10: Typical clay, clay and chert fill extraction site, showing isolated and sterilized materials due to water invasion.

- Water invasion can only be avoided by the reduction in extraction depth, which would essentially have the same effect as the current use of the earthen berms; i.e. it would require the increase in the footprint of the extraction area to yield the same volumes.
- Restoration of these sites will not be possible as all materials are extracted from the site to be used as fill in other areas; therefore, the sites have to be converted to another use.
- The sites may be designed prior to extraction commencement for three possible uses:
    - The creation of smaller more manageable ponds with a road network that dissects the land area, ponds of dimensions 75- 100ft x 30-50ft maximum (dimensions based on extension length of excavator boom). This can be achieved by planned extraction where the material is removed in a single episode and stockpiled adjacent to the pond for future removal or transportation.
    - The design of the extraction site that allows for areas of land to be left between the created ponds that can be used for residential purposes, the ponds can be designed to be more aesthetically pleasing and the area grassed and planted with trees upon completion so that the area could serve future recreational uses.
    - The creation of one large pond from the area of extraction (this can be applied to areas already extracted), this can be achieved by the return to these areas within the dry months and the use of water pumps to remove the water and then extract the barricades and separating berms to create one uniform pond. This method is more expensive and requires capital investment post extraction.

Pine Ridge Sand (quartz sand) Quarries and on land Gravel Quarries

Both of these types of materials are quarried in similar fashion where the deposits are limited in vertical depth, so they are scraped and material removed.

- Due to vertical depth limitations 1m to 3m in some instances, these sites inherently will have a large lateral footprint.
- Site restoration is possible for these locations as extraction can be done by elevation re-profiling by the overall reduction in the elevation to the base of the available material.
- Retention of topsoil is required.
- Extraction can be done in cells, when total available material is extracted from that cell, topsoil can be replaced, and spread to create a similar topographic profile just at a lower elevation, then extraction can proceed to the next adjacent cell.

Limestone and Marl Quarry

Unlike typical limestone and marl quarries where a hillock is excavated, this location has only a small vertical elevation difference as compared to the surrounding topography, this therefore requires that the material is scrapped and removed.

- Limit extraction to elevation of surrounding topography to ensure that no ponds or pits are created.
- Topsoil is thin at best and would be difficult to retain from this location.
- Scrape and remove friable material, with any boulders beyond the useable size range being left behind or broken through mechanical means.
- Extraction is done through topographic re-profiling to lower the elevation by removal of the material to a level similar to the surrounding topography.
- Prior to the decommissioning of the site, spread materials into any lower sections or pits created and slope any areas of extraction to a maximum 1:3 ratio to allow for natural re-vegetation. The presence of the marls makes natural reclamation by native vegetation a fast process.

6.3.4 Impacts Associated with Other Earthworks

The rehabilitation of the stretch of road will require major earthworks by scarifying the existing road surface and shoulders. These works will allow for the improving of the final vertical alignments by adding new pavement material and blending with the scarified material. Sections of road pavements that are determined to be unsuitable will be removed and replaced with appropriate base course material. These construction activities will be carried out with minor disruption to the traffic.

In addition, minimal earth-moving activities associated with road realignments will be necessary since most alignments will be occurring within the existing right of way. Horizontal Alignments in a few low lying may require some level of excavation where the geology of some of these sections may not be suitable sub-base material. These areas in general would require the importation of sub-base materials from identified sites above to allow for appropriate highway elevation along these new sections. These earthwork construction activities inclusive of those involving the replacement of existing culverts and the possible construction of a new Mexico Creek Bridge could negatively affect adjacent water bodies (wetlands and creeks), if proper procedures are not followed.

These impacts however, are assessed as moderate and temporary in nature and readily mitigated so that the residual impacts of the earth moving activities in this area are almost negligible. Much of the material excavated from these activities may be able to be incorporated as fill material for low-lying community lands (football fields, parks etc).

6.3.5 Mitigation Measures

The following mitigation measures are recommended to be observed during the construction stage of the highway to ensure that road rehabilitation activities related to earthworks do not have a significant adverse impact are as follows;

- The removal of vegetation is to be confined to the road footprint or range of operations within the road reserve for the longitudinal drains and culvert outfalls. The removed vegetation is to be mulched and placed on the road embankments together with topsoil.
- The removed topsoil is to be reused by placing on the road embankments. Excess unwanted excavated material is to be placed in approved designated sites where it would pose no risk to contamination of wetlands or water.
- The increase in traffic and the presence of road construction equipment during the road construction is to be regulated with temporary speed bumps, proper signs and flagmen on a permanent basis during the execution of the works.

- In section 1A local traffic from the area will be diverted from the Lords Bank junction to connect through to Perez Road connecting to Javier Berbey Garcia Boulevard and unto the Highway. This diversion section will be rehabilitated for it to serve as a temporary by-pass for the increased flow of traffic during road construction activities.
- Heavy construction equipment is to be properly maintained and monitored to ensure that the spillage of oil or fuel is avoided. Refuelling of all construction equipment is to be made at the designated base camp.
- Provide open, unlined longitudinal side drains which are cheaper to construct, and which have the advantage of an indefinite life and maintenance can be carried out using excavation equipment that is widely available. Drains in the suburban areas are to be covered and/or lined and built under the sidewalk.
- Proposed longitudinal side drains are to be provided with culvert crossings to allow access to private property and side access roads in rural areas.
- New and replaced culverts are to have a minimum diameter of not less than 24 inches for access road culverts and 36 inches for highway crossing. The culverts are recommended to be of reinforced concrete cylindrical or box type.
- Bridge works such as the abutments of the bridge are to be located outside of the banks of the creek with stabilization of the banks to prevent erosion. Excavation works are to be minimized and wing dam or sediment curtains placed around these works to prevent excavation material and debris from entering the Mexico Creek. The natural riverbed is to be re-established if found to be altered from previous construction works.
- The bridge is to be raised above the existing flood levels and the riverbanks stabilized to mitigate against flooding and erosion, respectively. In addition, river cleaning measures are being proposed for upstream and downstream obstructions to be removed to allow free flow, thereby reducing the potential for flooding. It is also recommended that MOW explore performance service contracts (in the long term) with local governments for the maintenance of these streams, creeks, and drains.

6.3.5.1 Mitigation Measures to Reduce Earth Movement Activities Impacts

The contractors will be required to employ the following Best Management Practices and engineering standards during earth moving operations:

- Stripped pavement material containing bitumen and other hydrocarbons will be recycled though it is possible to be used for the repair of streets or roads within communities in the study area,
- Material removed from horizontal alignment areas will be made available as possible fill for low-lying areas.
- The removal of vegetation is to be confined to the road footprint or range of operations within the road reserve for the longitudinal drains and culvert outfalls. The removed vegetation is to be mulched and placed on the road embankments together with topsoil.
- The removed topsoil is to be reused by placing on the road embankments.
- Careful soil stripping and storage, as well as site restoration will ensure that the potential geological impacts are minimized.
- Road be adequately sloped (maximum of 1: 3 ratio) in rural areas to stabilize and restore impacted areas as well to prevent soil erosion due to heavy rains.
- Seed or plant temporary vegetation for erosion control on new road slopes or where construction is not immediately planned.
- Geomats (Figure 6.11) could be used in areas with high organic contents for ground stabilization of unbound layers particularly along the new proposed alignments.

Figure 6.11: Geomats used for ground stabilization.

- Cover stockpiles and excavated soil with secured tarps or plastic sheeting.
- Schedule excavation and grading work for dry weather.
- The increase in traffic and the presence of road construction equipment during the road construction is to be regulated with temporary speed bumps, proper signs, and flagmen on a permanent basis during the execution of the works.
- Heavy construction equipment is to be properly maintained and monitored to ensure that the spillage of oil or fuel is avoided. Refuelling of all construction equipment is to be made at the designated base camp.
- Perform major equipment repairs, refuelling, or maintenance away from the job site. Refuelling area should be a bermed area away from storm drains and water bodies.
- Watch for soil and ponded groundwater that may be contaminated with oils and use sawdust to soak oils, which could be place in a drum and safely burnt where it would not affect any resident.
- Use check dams or ditches to divert runoff around excavations and graded areas.
- To prevent excessive siltation of adjacent areas during earth moving activities, storm-water will be diverted away from construction area and storm-water generated within the construction area will employ the use of check dams (Figure: 6.12) along the storm-water drains before discharging into the receiving environment.

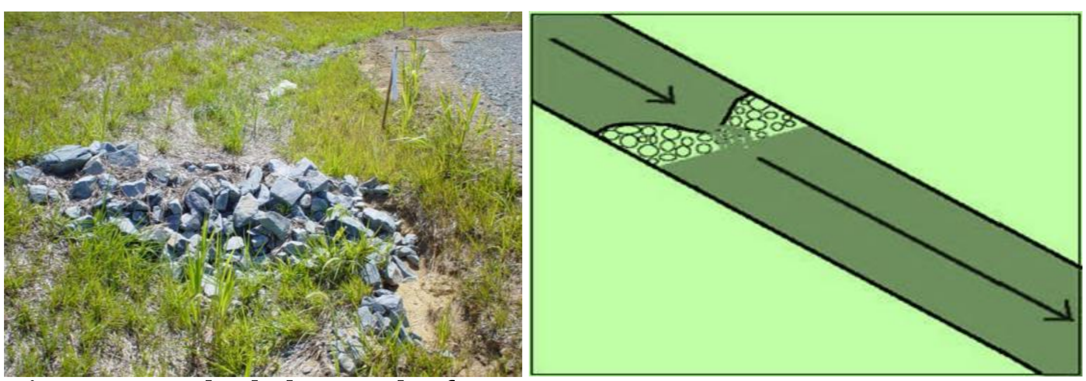


Figure 6.12: Check dam made of stones.

- The construction of bridge abutments for the possible replacement of the Mexico Bridge will involve the installation of mitigation structure such as wing dams made of sand bags, river stones, or the use of silt curtains (Figure 6.13) to prevent excessive siltation of the creeks in the area recognizing that this creek discharges into the Belize River above BWSL's abstraction point in Double Run.

Figure 6.13: Wing Dams (L) Silt Screen (R) Natural rocks.

- These structures will be deployed to enclose the construction area within a semi-circle that extend to no more than the mid- point of the width of the creek to allow for unimpeded water flow (Figure 6.13). Following construction work, the silted area within the wing dam or silt curtain will be cleared of excessive sediments before their removal.
- To reduce the impacts associated with materials supply, only sites identified above that meet the set of pre-determined criteria will be utilized. To mitigate the impacts on any one specific selected site, the extracted volumes will be shared among the different sites to reduce the environmental impact footprint.
- Extraction of materials will be done by levelling sites evenly and preventing ponding. The disturbed areas will be restored to as close as their original natural state as possible.

6.4 Hydrology/ Flood Risk Management Plan

6.4.1 Drainage and Flooding in Study Area

The proposed rehabilitation section (miles 8.5 – 24.5) of the PGH traverses the lower sub-catchment of the Belize River watershed: a characteristically flood-prone region of the Belize District. The study area is defined as a band four kilometres (km) east and four kilometres west of the centre line of the current road.

The sections of the highway most vulnerable to floods are described as follows:

The PGH in the Ladyville area and between the airport road and Price Barracks Road has longitudinal drainage culverts and outfalls that are ineffective, and has been compounded by the suburban development in the area.

The Double Run Water Treatment Plant access road: Floodwaters are known to inundate the Double Run Plant and access road to its junction with the PGH; there is a need to provide interconnection between marshy areas particularly when these are over topped in extreme events.

The zone from Mexico Creek Bridge through to Gardenia, where the PGH traverses the wetlands interconnected with the Mexico/Jones Lagoon system and Mexico Creek. The section of the highway has been submerged with 6 to 12 inches (5.25 cm to 30.5 cm) of floodwater for about 0.5 mi. (0.8 km) distance on two or more occasions during the past ten years: while high-energy floodwaters through Mexico Creek have strained the Mexico Creek Bridge infrastructure.

The Mexico and Jones Lagoon act as natural catchment areas for the surrounding terrain and during the rainy season overtop and discharge into Mexico Creek, which in turn discharge into the Belize Old River. However, during extreme events (TD 16, 2008; Hurricane Keith 2000) the Belize Old River overflowed its banks and rose to such an extent that there was a reversal of flow in Mexico Creek towards Jones Lagoon. The flow reversal, floods the low-lying flat areas on the east side of the PGH. After the flood waters peaks the water levels become stagnant and take an extremely long time to subside. This is because of the damming effect caused by the PGH in these flood prone areas. Such conditions dictate the need of equalizing culverts at appropriate intervals along this section of the PGH based on the hydraulic studies to be carried out.

The micro-catchments in the zone are Mexico Creek, Mussel Creek, and Black Creek. The vulnerability of this section of the highway was very evident during recent extreme weather events (TD 16, 2008; Hurricane Keith 2000); resulting in failing pavement, bridge infrastructural damage, and traffic disruption.

In summary, this stretch of Philip Goldson Highway is critical as an emergency transit route from Belize City. The lower limit of the highway is near sea level, so there is an elevated risk of flooding during hurricane events when hurricane-forced winds and low pressures generate storm surges, and torrential rainfall dramatically increases flow in the lower Belize River basin.

6.4.2 Results of Hydraulic Modelling

The general results of the hydrology and hydraulic study conducted by Golder show:

1) Current PGH elevation (crest) from Mile 8.5 to 24.5 is above the 1:2-year flood water levels for all modelling scenarios;
2) Current PGH crest for the Mile 8.5 – 24.5 road segment is generally above the 1:5- year flood, except for about 1.5 km around Mexico Creek crossing under future modelling scenario without storm surge modelling scenario;
3) Rarer flood water levels surpass the PGH crest over longer lengths particularly for flood return periods higher than 25 years. The PGH crest for approximately 1 km segment in the Ladyville area and about 1 km road segment beyond the Burrell Boom road junction is below the 1:10-year flood water levels under future scenario without storm surge;
4) Storm surge impact on the downstream 10 km of the Mile 8.5 – 24.5 segment inundates the road with the 1:100-year flood water levels, projected to be as much as 5 m above current highway crest. One mitigation action for storm surge would require a dyke along the entire coast line, which would be prohibitively costly.

Following deliberations with MOW's engineers, Golder, and other stakeholders, the following criteria were proposed for the PGH road design for the segment from Mile 8.5 to 24.5:

- Storm surge flooding risks are not considered in the PGH design.
- The PGH Mile 8.5 – 24.5 segment should be designed not to get inundated for the 1:25-year Belize River flood (i.e. future conditions, without concurrent storm surge).
- Notwithstanding criteria 1 and 2 above, the Mexico Creek bridge crossing should be designed for the 1:50-year Belize River flood (future conditions, no concurrent storm surge), with 0.5 m of freeboard between maximum water level and bottom elevation of the bridge girder.

6.4.2.1 Golder Associates Ltd. Recommended Flood Mitigation Options

Golder's conceptual flood mitigation options to reduce the effect of the Belize River for the PGH Zone of influence examined the following:

1) Construction of the Vista del Mar Canal;
2) Haulover Creek Cleanup;
3) Mexico Creek Canal.

4) Clover Leaf Canals

Subsequent field analysis, hydraulic modelling and further discussions with MOW's engineers, and other key project stakeholders, Golder submitted the updated flood mitigation options for the PGH based on the list of criteria for its propose road designs. A discussion of these options is found in Section 2.0 on Alternatives.

6.4.2.2 General Impacts of Proposed Linking Canal

The recommendations pertaining to the potential link canals were presented as possible conceptual scenarios aimed at alleviating the flooding resulting from the backflow of the Belize River during top-gallon flooding. It was pointed out that the concept to bifurcate the Belize River at the point of the Mexico Creek could have significant environmental. social and economic implications far greater than those possibly associated with the current rehabilitation of the highway and are outside of the scope of what can be practically considered in these studies. Even the smaller link canal at the Vista Del Mar area could have significant environmental and social impacts, which would need careful consideration. The concept for the link canal to link the Belize River out to the sea is to divert a portion of floodwaters to reduce road overflow. As mentioned, an open canal carrying tens of cubic metres of water per second would be predicted to have very significant environmental impacts, including sedimentation of nationally important seagrass beds just off the coast of Ladyville – which in turn would impact the food resources for Belize's largest population of endangered Antillean manatees.

These negative impacts would be reduced considerably by the suggested installation and operation of canal gates if opened only when needed in and after storm events to help prevent road flooding, and thereby avoid year-round outflow and sediment transport. Effective operation of such gates would also largely alleviate risks of allowing saline entry to the River 5+km upstream from the mouth, and thereby 5+km closer to the water treatment station at Double Run.

It is important to conduct the necessary studies on what the impact of these would be to the coastal ecosystem and wetlands. It is also important to carefully assess what impacts these proposals would have on salt-water intrusion in the Belize River and the current salt-water wedge with respect to the various water abstraction points along the Belize River. These are to remain as concepts until the necessary level of detailed studies on these could be conducted.

6.4.3 Local Drainage: Flood Alleviation from Torrential Rainfall

The proposed rehabilitation section (miles 8.5 – 24.5) of the PGH traverses the lower sub-catchment of the Belize River watershed and lies within a flood-prone region of the Belize District. The study area suffers from poor drainage and ineffective culverts that are insufficiently sized and in many instances clogged severely restricting the free flow of water between the wetland areas separated by the highway, which currently acts as a dam cutting through these wetland areas. There are several sections of the highway where the longitudinal drains along the highway have no discharge outlets.

The PGH in the Ladyville area and between the airport road and Price Barracks Road has longitudinal drainage culverts and outfalls that are ineffective, and has been compounded by the suburban development in the area.

6.4.3.1 Golder Associates Ltd. Proposed Mitigation Measures on Drainage

The preliminary highway design also included recommendation to address drainage, which consisted of the following:

1. 2.5 % cross fall on normal crown areas;
2. Super-elevation on curves to match design speed;
3. Required to acquire land on the west side for a canal in urban area. In constrained areas the sidewalks could form the capping of a concrete culvert for a closed storm sewer system;
4. The road profile should be raised in all areas and significantly in sections with historic flooding (e.g. Mexico Creek and Ladyville). Measured freeboard will be derived from hydraulic analysis of design year flood elevation;
5. Freeboard to the edge of travel lane = 1.0 m
6. For the Section 1A: Ladyville- a closed storm drainage (box culvert under sidewalk) where property unavailable for a roadside ditch or canal;
7. New outlet for storm drainage (south end project limit Link canal and Poinsettia Street Canal);
8. For the Rural Section 2B: Sandhill to north of Mexico Creek Bridge - Grade raised over and north of Mexico Creek (1.0 m above design floodplain elevation).

9. Replacement and Construction of all existing culverts with culverts that are no smaller than 36 inches.

6.4.3.2 Additional Proposed Drainage Mitigation Measure

In addition to those measures proposed by the Technical Feasibility Team there is the need to improve drainage in the area by ensuring that drains are properly sized and have discharge outlets either to the sea or river to prevent the localized flooding that occurs as a result of torrential rainfall and the present ponding of storm water. Like Golder, it is recommended that more than half of the existing culverts be replaced with properly sized and positioned new ones since many of them are in a deteriorated conditioned and their capacity diminished by blockage. Annex XV provides more detailed information on the culverts of the project area with their locations shown in accompanying maps. There may also be the need for new additional balancing or equalizing culverts to properly restore the two-way flow of water between adjacent wetland areas. To alleviate drainage conditions a number of improvements will need to be made to the local drainage in the study area as a means of mitigating the impacts of floods on the highway and communities of the area.

6.4.3.2.1 Vista del Mar and Airport Junction, Ladyville

Vista Del Mar Storm Water Drain – This 10 feet wide storm water main link drain was dug in the 1980's to provide drainage to area and would serve as a major conduit for storm water from the entrance area of Ladyville and would channel river backflow water towards the sea. This ditch has become overgrown with bush and overtime has lost its connectivity due to lack of appropriately placed culverts during the present road alignments and improvements to the highway in this specific area. As such, this non-functional main linking drain is to be re-defined or re-habilitated. Longitudinal side drains are recommended along the PGH from the Our Lady-of -the- Way RC School, Ladyville up to the main linking drain near Estephan's property (immediately south from the Airport Road junction).

Wetland on the Airport side will connect to the rehabilitated main linking drain via eight existing, 6-feet box culverts on the Old Northern Highway in the area, and four existing culverts along the existing PGH. Two new culverts are recommended to be placed directly in line with the existing drain's trajectory and to connect the two new culverts in front of Mr. Estephan's Property by means of an enclosed lateral drain connecting to the main linking drain.

The main linking drain is to be cleared and dredged up to the Vista Del Mar Marina and possibly lined. The engineering specification of the proposed rehabilitated main link drain will be presented in the preliminary road infrastructure design for the PGH. Figure 1.14 is a map showing the proposed trajectory of the main linking drain and the longitudinal drainage in the Ladyville area.

Indications are that the current main linking drain exists in private land, however, Mr. Estephan, who is one of the landowner is willing to cooperate with the Ministry of Works in this road rehabilitation project (BET personal communication) and believes that the other land owners are likely to do so since it is in their interest that this drain be improved to ensure proper drainage of their properties.

It is also recommended to re-establish an outflow from the wetland just south of the Old Airport road to the Belize River via a natural, narrow channel near Vista del Mar junction and to ensure that other drains connecting to the natural drainage system at the end of the international airway runway are improved to allow for proper drainage of the flood waters in these areas. Improve the channel along the old airport road; also establish drainage from the south side of airport road near large culverts to longitudinal side drains along the highway. In the populated areas, the drainage design should be concrete covered drains (see Figure 6.14).

Figure 6.14: Re-habilitate existing Main Drains (Blue Line) from near Estephan's Property to Vista del Mar Canal.

6.4.3.2.2 Flood - prone area between Marage Road Junction and the PGIA Road Junction

A flood relief drain is recommended running along the right side of Poinsettia Street eastward for three blocks then southwards up to Vista del Mar Marina/Canal system. In like manner, another drain is recommended to go along the Marage road for three blocks then southwards along Japan Road up to Vista del Mar Marina/Canal system. This will alleviate flooding in the Ladyville/Michelle Estate area and elsewhere to the east and north.

The proposal to establish drainage along from Marage Rd and Poinsettia St to Vista del Mar Marina/Canal system is supported by MOW's engineers. The drain should consider sediment traps and the use of weirs to trap debris before discharging into the Vista del Mar Marina/Canal system. The recommended, flood-relief drainage along Poinsettia Street and Marage Road is highlighted on the map in Figure 6.15 below.

Figure 6.15: Improved drainage along Poinsettia Street and Marage Road, Ladyville, eastwards then southward to the Vista del Mar Canal.

6.4.3.2.3 Ladyville to Lord's Bank Road

The Lord`s Bank access road longitudinal side drains are proposed to be reinstated and improved to enhance its hydraulic capacity for the removal of storm runoff from the PGH and the Lord`s Bank community in the event of extreme weather (Figure 6.16).

The longitudinal drain along the Lord's Bank Road should have its outflow into a sedimentation pond before the water overflows into the river.

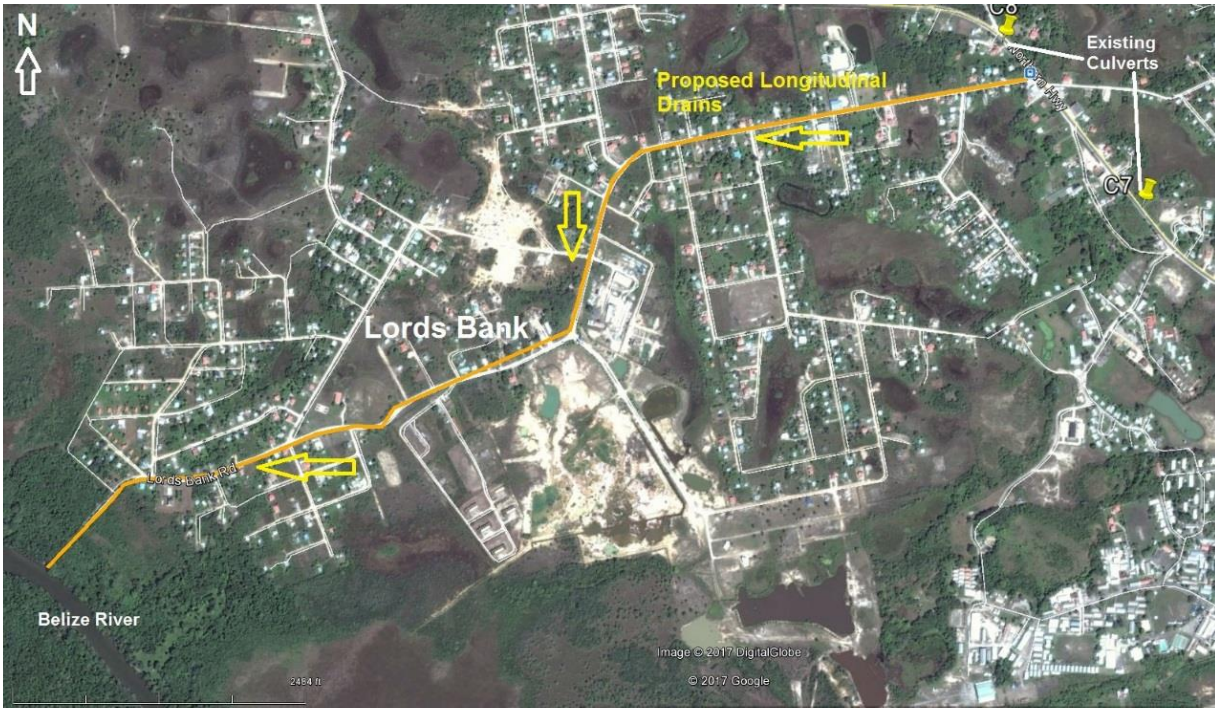


Figure 6.16: Proposed drainage along the Lord's Bank Road to the Belize River.

6.4.3.2.4 Lord's Bank Road to Burrell Boom Road

Mile 13 Drainage Canal to Existing Channel that Leads to the Sea

BET proposes a drain from near the junction of the Old Northern Highway (ONH) near 13 Miles, to run along the north side of the ONH for 0.8 km, then deviate to the north along an old quarry site for 0.4 m, then deviate NE to join and existing Channel (Calva Pond Creek) that runs eastwards, south of the Old Nova Shrimp Farm. The exiting Channel that runs to the Sea, can be rehabilitated to improve its hydraulic capacity and efficiency, to help drain excess runoff away from the Highway during future, extreme rainfall events. Figure 6.17 show the trajectory of this proposed drainage canal.

Impacts on the environment during the construction phase may range from vegetation and earth removal, erosion and increased sedimentation into existing channel, solid waste pollution and oil leaks into the soil and ground/surface water.

Some mitigation measures recommended are: employ construction techniques that minimize the loss of vegetation and soil removal, confine loose material in safe location to reduce sedimentation, practice proper solid waste management, and have proper storage for waste oils and grease.

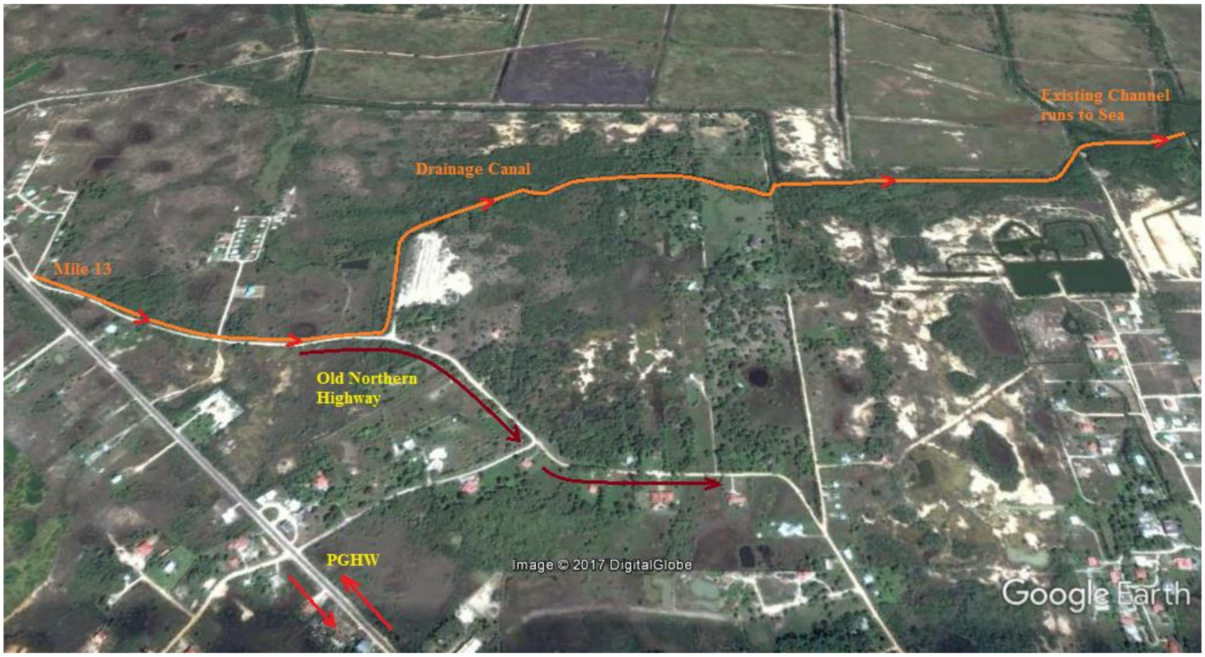


Figure 6.17: Drainage Canal at Mile 13 PGH.

Local topography survey along the Double Run access road to Belize Water Service Limited (BWSL) indicates that the elevation in the ROW of this access road is higher than the wetlands to the north, south, and east. A longitudinal drain from the junction with the PGH to the Belize River will have to be deep and costly. The proposal for improving the drainage in this zone with a longitudinal drain along the access road is questionable at this time. The other option is to consolidate the runoff in the natural low rush-pond to the north of the access road (Figure 6.18).

Figure 6.18: Natural low rush-pond to the north of the Double Run road.

This pond is the lowest spot just west of the highway. This ponding area can be rehabilitated to increase volume capacity. Any outflow towards the Belize River would encounter the constraint of higher elevation.

6.4.3.2.5 Burrell Boom Road to Sandhill

Improve longitudinal drains along the highway and divert outflow to low lying areas. Ensure proper work ethics and environmental safeguards during rehabilitation of the highway and infrastructures such as the roundabouts, culvert replacement, and drainage construction.

6.4.3.2.6 Sandhill to north of Mexico Creek Bridge

New, multiple flood-relief culverts and accompanying out-fall drains are to be provided. Presently, the road structure acts as a dam during extreme weather events, which does not allow the flow of water from either side of the highway.

Examine the need for the placement of additional equalizing culverts (Figure 6.19). Golder proposed that this section of the highway be raised by 1 meter. This proposal may require further investigation.

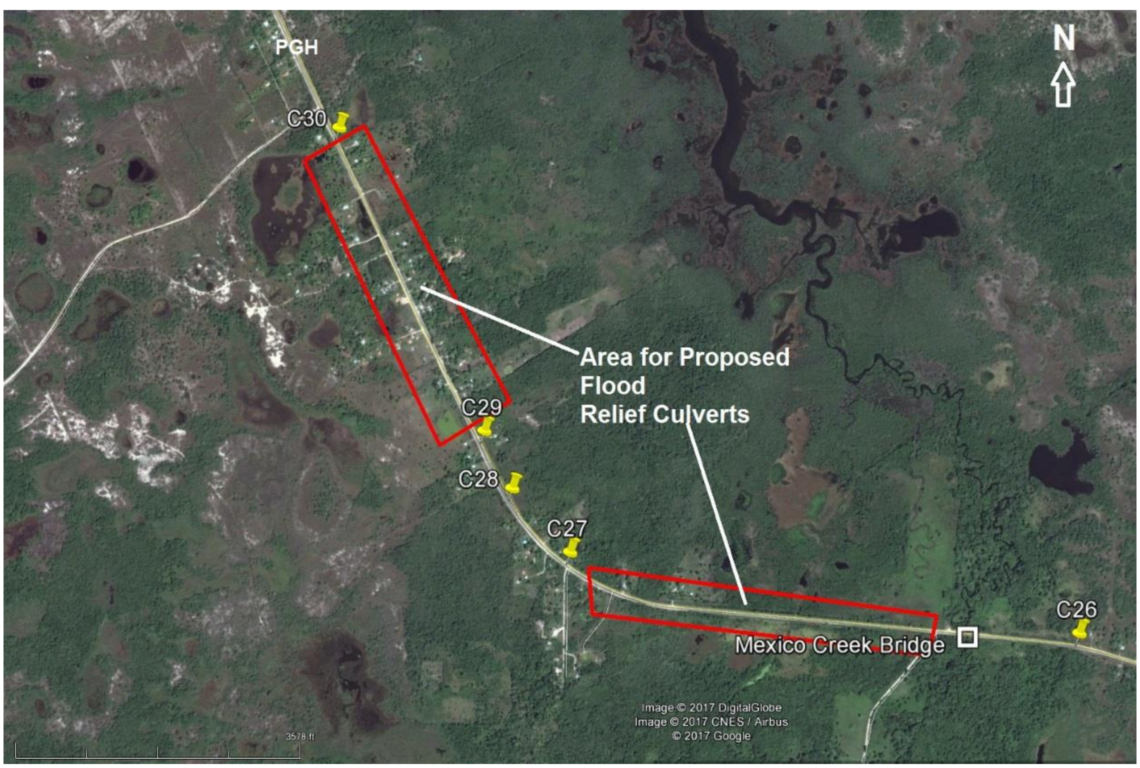


Figure 6.19: Area to be examined for the need of placement of additional equalizing culverts.

6.4.4 Summary of Mitigation measures to Relieve Flooding

- Existing longitudinal side drains and culvert outfalls are to be cleared and re-established to allow the free flow of storm water.
- A main linking drain in the Vista Del Mar area that exists and which used to cross the PGH at approximately Mile 9.4 is recommended to be reinstated or constructed by providing an appropriate crossing. The main linking drain will go from the west side of the PGH up to Vista del Mar Marina/Canal system on the east side. This re-habilitated main drain will assist in draining the longitudinal side drains of the PGH, which are connected with the airport drainage ditches located along the eastern perimeter of the airport. The purpose of these drainage ditches is to remove runway runoff from the marsh area. The drainage ditches flow in a southerly direction cross the airport road by means of a quadruple RC culverts (48-inch diameter) and into a low-lying marsh area and from there eventually up to the Belize Old River. The main linking drain once rehabilitated will assist in the removal of excess water from the marsh area thus alleviating the flooding conditions along the PGH.
- The re-establishing of the interconnection by means of existing culverts at the Double Run Plant access road junction with the PGH will allow the free flow of water to and from marshy areas. Balancing or equalizing culverts to be considered as possible measures to alleviate the flood conditions.
- The zone from Mexico Creek Bridge through to Gardenia, where the PGH traverses the wetlands interconnected with the Mexico/Jones Lagoon system and Mexico Creek. The section of the PGH from Mexico Creek Bridge through to Gardenia, where the PGH traverses the wetlands interconnected with the Mexico/Jones Lagoon system and Mexico Creek, will require the installation of new multiple flood relief culverts and accompanying outfall drains in the identified flood prone areas. Culverts and drains are to be properly designed and placed based on requirements as dictated by the hydraulic studies. The multiple culverts will allow connectivity for the two sides of the road in the flood prone areas and the long road embankment that acts as a dam is avoided.
- Of note is that similar flat low-lying terrain along the Philip Goldson Highway between miles 8 and 9 was also subject to flooding. The flooding of this section of the highway

was alleviated with the installation of double culverts (48-inch diameter) placed at 200 feet intervals.

The following additional operational measures are recommended to ensure that road upgrading activities do not have a significant, adverse impact on the hydrology of the area and its supporting wetlands, creeks, ponds and lagoons.

- No faulty heavy machinery with fuel or oil leaks will be utilized and equipment will be properly maintained and inspected when operating in wetlands areas or near existing water bodies (ponds, lagoons, or creeks).
- Provision of appropriately designed longitudinal side drains. When directing drainage into a water body ensure that the following are installed along the discharge point: 1. Oil interceptors, interceptor grate, and silt traps to prevent pollution by oil, grease, litter, and hydro carbons from the tarmac surfaces and the road reserve and 2. Erosion dissipating structures, especially at the discharge point to reduce the velocity of water into the water body during high rainfall periods to reduce the incidence of erosion.
- De-watering and watering work for structure foundations or earthwork operations adjacent to wetlands and water bodies shall be undertaken in such a manner to prevent silted water and eroded material from entering these. Intercepting ditches, wing dams for Mexico Bridge works, by-pass channels, barriers, settling ponds, etc. will be used to prevent any excessive sedimentation of these systems.
- Turbidity increases in water bodies nearby construction activities shall be avoided and closely monitored.
- Construction Camps shall be located in areas that are at least 100 meters from water bodies.
- Proper measures such as the use of portable toilets shall be provided at construction sites.
- Work Camps shall have acceptable temporary sewage and domestic wastewater disposal systems.
- Waste oil, grease and other contaminant shall be properly stored in closed containers placed in a bunded area.

- Runoff of storm water during construction shall be diverted to temporary natural settling ponds where practical and possible, with the construction of check dams along drains, to avoid direct flow of construction storm water into wetlands or other water bodies.

6.5 Water Quality

6.5.1 Road Rehabilitation Impacts on Water Quality

The proposed rehabilitation section (Miles 8.5 – 24.5) of the PGH traverses the lower sub-catchment of the Belize River watershed; a characteristically flood-prone region of the Belize District. Micro-catchments in the zone are Mexico Creek, Mussel Creek, Black Creek, the Crooked Tree Lagoon System, and the lower Belize River. The vulnerability of this section of the highway was very evident during historic flood events (Tropical Depression 16, 2008; Hurricane Keith 2000; Tropical Disturbance/Cold Front system interaction, November 1979, etc.), which resulted in failing pavement, bridge infrastructural damage, traffic disruption and community impacts.

Specifically, the sections of the highway most vulnerable to floods are the Vista del Mar/Ladyville area, Double Run area, and the section around Mexico Creek Bridge to Gardenia. One-foot or more of floodwater in some sections submerged the highway during intense rainfall events on several occasions during the past ten years; while high-energy floodwaters through Mexico Creek have strained the Mexico Creek Bridge infrastructure. Farther up at Gardenia Village, the highway runs through a floodplain, with wet lands or 'bajos' on either side. The Village is often affected by floodwater from nearby Mexico Creek, making life unbearable for residence, coupled with water-borne pests and diseases.

Therefore, the study looked at areas that are prone to flooding, areas, which are prone to slow run off, and water bodies near the road, especially the area traversed by Mexico Creek and areas where placement or replacement of culverts, and drainage are required.

There is likely to be three main types of impact associated with road construction and associated activities:

- discharges of contaminants to receiving waterways (e.g. storm water run-off from elevated gradients on the road and construction camps, run-off from vehicle wash-down areas);

- disturbance of the Mexico Creek watercourses directly through physical works, and indirectly due to run-off containing suspended solids from removal of stone debris left during the construction of the Mexico Creek Bridge or possible replacement of entire bridge;
- Accidental events or pollution such as spillage of fuel, oils, or cementitious material.
- Sewage and Waste Disposal from worksites and Work Camps.

In terms of standards or impact prediction, these types of impact do not lend themselves to being easily quantified. Notwithstanding this, it can be pointed out that the magnitude of impacts to water quality can be considered very small to small. That is:

- Direct or indirect impacts largely not discernible.
- No effect on users, spill or accidental event that causes immediate area damage only and can be restored to an equivalent capability in a period of days or up to a month, i.e. full restoration is achieved as a result of immediate clean-up operations.
- Physical disturbance of watercourse (Mexico Creek) limited to immediate working area.
- Visible sediment and obscuration of watercourse bed (Mexico Creek) observed for less than 1 week.
- <15% decrease of downstream creek flow rate for no more than 1 week.

The parameters of specific interest to monitor water quality are turbidity, total suspended solids, total and fecal coliform, dissolved oxygen, pH, nitrates, phosphates, salinity and oil in water. **(See Section 4.10.2 and Annex XI for Water Analysis Results)**

TSS/Turbidity: Suspended **solids** in water can be measured by measuring for total suspended solid (TSS) or turbidity. Turbidity is a water quality term that refers to fine suspended particles of clay, silt, organic and inorganic matter, plankton and other microscopic organisms that are picked up by water as it passes through a watershed. Turbidity in surface water bodies usually has organic and inorganic matter. Table 6.2 shows lowest and highest readings which are all well below the 25 NTU reading which is considered murky. Note that turbidity increased from one month to the next due to the rains, which caused greater water runoff into the water bodies.

Table 6.2: Turbidity Readings (NTU).				
Date	Mar 2017	Sample Site	April 17	Sample Site
Lowest	2.29	Jones Lagoon	5.88	Jones Lagoon
Highest	14.6 13.9	Upper Black Creek Wash Pan, Black Creek	16.1	Belize River

Bacteriological Quality: In March, of the eight samples taken, all tested positive for fecal *coliform* and all except for Jones Lagoon, tested positive for *E. coli.* In April, Jones Lagoon and Mussel Creek tested negative all the rest tested positive. The laboratory test does not discern from what source(s) this contamination occurred, all indications are that in the absence of a large established human population in the area tested, the water is being contaminated with fecal matter through animal waste. This can be due to pasture land being located along the water bodies and wildlife such as howler monkeys and tapirs. Table 6.3 gives a summary of the results.

Table 6.3: Bacteriological quality of the Water Sampled March and April 2017.				
	Fecal *Coliform*		***E. coli***	
Sample Site	**Mar**	**Apr**	**Mar**	**April**
	counts/100ml			
Jones Lagoon	**10**	**0**	**0**	**0**
Black Creek 1 Upper	**14**		**10**	
Black Creek 2 Wash Pan	**12**		**12**	
Black Creek (bf May Pen Bridge)	**110**	**60**	**100**	**20**
Mexico Creek (Confluence wt Belize River)	**100**		**90**	
Mexico Creek (Mexico Bridge)	**40**	**50**	**30**	**22**
Mussel Creek 1	**50**	**0**	**48**	**0**
Mussel Creek 2	**26**		**24**	
Belize River (Bt Mussel Creek and Mexico Creek)		**60**		**16**
Lowest	**10**	**0**	**0**	**0**
Average	**45**	**34**	**39**	**12**
Highest	**110**	**60**	**100**	**22**

Both BWSL's Acceptable Limits and WHO's Guidelines for drinking water are 0 counts/100ml for both fecal *coliform* and *E. Coli*, therefore caution should be taken if these waters are to be used for drinking. These waters must be boiled or chemically treated if it to be used for drinking. The Standard for recreational waters is 100 counts for 100ml for both. Should the waters have a higher concentration than this, the public must be advised that the waters are not suitable for swimming.

Notwithstanding the presence of Bacteriological contamination, measures should be taken to avoid human contamination via improper sanitary facilities for construction workers and base camp activities.

Dissolved Oxygen

Very low concentration of dissolved oxygen in a water body is detrimental to aquatic life as it could lead to fish kill. The minimum amount to sustain aquatic life is around 4 -5 ppm

The dissolved oxygen concentration was within the acceptable range at the Jones Lagoon. In March 2017, the in situ reading at the sampling points of Black Creek before the May Pen Bridge and at Mexico Creek Bridge were below the MCL. In April 2017, only Mexico Creek Bridge showed a decline in DO concentration, while Black Creek's DO concentration improved above MCL. The sample taken of the Belize River for this same date (April 2017) indicated a very low DO concentration of 2.85 ppm and Mexico Creek Bridge had an average low DO reading of 2.21 ppm. *These results indicate that mitigation measure should be strictly adhered too when working at the Mexico Bridge and Mexico Creek.*

pH and Alkalinity

The pH or "potential of hydrogen" is the measurement of the acidic or basic/alkaline condition in the water and alkalinity refers to the capability of water to neutralize acid. This basically means the water capacity to resist changes in the pH which would make the water more acidic. The normal pH range for surface water is 6.5-8.5 and living organisms, especially aquatic life, function best in a pH range of 6.0 to 9.0

All of the pH values found throughout the sampling locations indicate that the waters are slightly alkaline to alkaline in nature. Also all readings fell within the acceptable ranges of alkalinity of 30 to 250 mg/l. Therefore, all water bodies have some sort of buffering capacity. The highest alkalinity concentration was Mussel Creek and Belize River while the lowest alkalinity concentration was at Jones Lagoon and Mexico Creek. *Here once again, results indicate that mitigation measure should be strictly adhered too when working at the Mexico Bridge and Mexico Creek.*

Nitrate- Nitrogen

The major sources of nitrates in water are run-off from fertilizer use, septic tank leakage, animal manure, and release from natural deposits. The MCL for nitrate-nitrogen is 10 mg/l.

Despite the presence of pasture land and wildlife along the Mussel Creek, Black Creek and the Belize River banks, nitrate-nitrogen concentration found at all these locations was very low.

Phosphate

There is no MCL for phosphate in potable water since phosphates are not toxic to people or animals unless they are present in very high levels. Digestive problems could occur from extremely high levels of phosphate (Water Research Center, 2017).

In analyzing the lab results it showed that the sample locations had very low concentration of phosphate ranging from 0.03 mg/l to 0.11 mg/l during the months of March and April, 2017.

Salinity

In analyzing, the salinity data the water at each sampling site is considered freshwater as the salinity found ranged from 0.37 ppt to 6.36 ppt. It should be pointed out that salinity increased at Jones Lagoon, Black Creek and Mussel Creek and the Belize River from March to April 2017 while Mexico Creek the salinity decreased.

6.5.2 Solid Waste Disposal

BET recommends that all construction solid waste be stored temporarily in 15 cubic yards or 20 cubic metal construction dumpsters and domestic waste be temporarily stored in smaller metal dumpsters on site and to be permanently disposed of at the newly opened Burrell Boom [Solid Waste] Transfer Station (See Figure 6.20).

Figure 6.20: Burrell Boom [Solid Waste] Transfer Station. (Source SWAMA, Belize 2017.)

Material removed from the existing road pavement will be evaluated and reused if it meets the road construction standards. It can also be used for improving the communities' unpaved roads. This material can be stocked piled along with the new material to be used.

Notwithstanding this improper and illegal dumping of all manner of solid waste remains a countrywide problem, as well as littering the highway with plastic and foam containers, posing significant threats to human health through unsanitary conditions, pollution of groundwater and other potable water sources. Improper solid waste sites become habitat for rats and other pests able to harbour and transmit diseases, and providing conditions for water capture suitable for breeding mosquitoes, with associated issues of Malaria, Dengue and Zika. The buffer area of the Highway is no exception. Dumping was observed off a side road near Los Lagos, and is intermittently observed on the verge of the Highway itself in other places.

It is however unclear whether the condition of the Highway has any impact on illegal garbage disposal of this nature, or whether it is the most travelled route for people with garbage to dispose of. Factors having a greater influence include access to approved dump sites, availability of garbage collection services, lack of public awareness about the health and environmental hazards of such dumping, and lack of enforcement of applicable legislation. The opening of new access tracks to access fill material, to create material storage compounds, and to access the Black Creek, Mexico Creek and Mussel Creek waterways, poses the biggest risk of increasing illegal dumping, and is addressed by appropriate mitigation actions in the Mitigation Plan. The upgrading of the Highway is therefore assessed as having medium **incremental** negative impact on illegal dumping of solid waste.

6.5.3 Mitigation Measures to prevent Impacts to Water Quality

In addition to Bacteriological contamination due to the presence of pasture land for cattle rearing and wildlife, and illegal garbage disposal, the majority if not all of the project area can be considered as disturbed. This however does not imply that measures should not be carried out during road rehabilitation activities to minimize further adverse impact on the water quality of the surrounding area. Outlined are some of the measures to be taken.

- Minimize problems with soil erosion and sedimentation from earth moving activities or debris removal while conducting the clean-up of the Mexico Creek, Mussel Creek, and Black Creek, by employing BMPs for soil erosions as recommended in the section on geology.
- Construction activities should be managed to prevent entrance, or accidental spillage of solid matter, contaminants, debris and other pollutants and wastes into streams and watercourses.
- Dewatering road sections under construction or earthwork operations adjacent to or encroaching on streams or water works or watercourses shall be conducted in a manner to prevent muddy water and eroded materials from entering the streams or watercourses by constructing intercepting ditches, check dams, wing dams, siltation curtains, by-pass channels, barriers, settling ponds.
- Ensure the responsible storage and handling of petroleum products especially during refuelling. Limit this activity as much as possible.
- Maintain equipment in good operational condition, free from any oil and fuel leaks.
- In the event of a spill, use absorbent material to clean up and place contaminated material in a plastic drum that is to be kept covered at all times and report any spill immediately to DOE.
- Ensure that any aboveground fuel storage tank is placed within a bunded area that is able to contain more that 120% by volume of the largest tank. Store waste oil within bunded area in sealed plastic containers and contact DOE for final disposal.

- Construction workers will be required to ensure that the area is kept free from litter at all times and that all domestic waste is properly containerized and disposed of.
- Provide proper sanitation facilities for worker at work spots and base camps.
- No motor vehicle or equipment of any other type shall be washed in any river, stream, or lagoon.
- All proposed campsite locations will be submitted to DOE for vetting. The campsites will be located away from any waterways with the required human amenities, which will be serviced on a regular basis.
- Conduct public awareness about the health and environmental hazards of illegal dumping.
- Increase enforcement of applicable legislation(s).

6.6 Noise, Air Pollution and Vibration

6.6.1 Sound and Noise

Noise pollution is an undesired sound that is disruptive or dangerous and can cause harm to life, nature, and property. The hazardous effects of noise depend on its intensity (loudness in decibels), duration, and frequency (high or low). Noise may be ambient (constantly present in the background) or peak (shorter, louder sounds) (International Encyclopedia of the Social Sciences, 2017). Table 6.4 below provides the Second Schedule (Regulation 42) Noise Level from the Pollutions Regulations, which establishes the noise level standards for Belize.

Table 6.4: Pollutions Regulations Second Schedule (Regulation 42).

NOISE LEVELS
Noise Level According to the dB (A) Scale (as defined by the International Electronics Commission)

Duration of the Noise	Structure									
	A		B		C		D		E	
	D	N	D	N	D	N	D	N	D	N
1. More than 9 hrs.	60		60		70		70		85	
2. More than 3 hrs., less than 9 hrs.	70		70		75		75		90	
3. More than 30 mins.	75		75		80		80		100	

4. More than 30 mins.		45		45		45		45		90
5. More than 15 mins., less than 1 hr.	70		70		90		90		105	
6. More than 10 mins, less than 30 mins		45		50		50		50		90
7. More than 5 mins and less than 15 mins	70		85		100		90		90	
8. More than 2 mins and less than 5 mins	90		95		100		100		95	
9. Less than 10 mins		50		70		70		70		80
10. Less than 2 mins	100		100		105		100		110	
Noise from infrequent (less than 4 time per week) explosions	109		109		114		114		114	

D= Day N=Night
Structure A: any building used as a hospital, convalescent home, old age home, or school.
Structure B: any residential building.
Structure C: any building in an area that is used for residential and one or more of the following purposes: commerce, small-scale production, entertainment.
Structure D: any residential apartment in an area that is used for industry commerce or small-scale production.
Structure E: any building used for the purposes of industry, commerce, or small-scale production in an area used for the purposes of industry, commerce, or small-scale production.

There are three main sources of noise that will affect the highway construction crew and communities along the Philip Goldson Highway project area, namely:

- Construction of the highway.
- Increase in highway construction equipment traffic and personnel transportation.
- Quarrying and its associated activities of excavation, and transportation of highway material from existing material pits near or off the project highway.
- Increase of traffic including speeding along the highway as a result of the rehabilitation of the highway.

6.6.1.1 Construction and Transportation Noise

The project area has high noise levels at specific times of the day (6:00 am to 10:30 am and 4 pm to 7:00 pm) from the Vista del Mar intersection to the Lake Gardens intersection, the most populated section of the road (Section 1) which can be considered as somewhat harmful to the environment (humans and fauna). It should be noted that of all vehicular traffic, with a few exceptions, the passenger buses, tractor-trailers (tow heads) and dump trucks (ten wheelers) tended to record a higher noise level when compared to other vehicular traffic.

The highest reading at 99.5 dBA was at the Vista del Mar Junction. This junction also recorded the highest ambient and minimum noise levels. The higher levels of noise recorded at the Vista del Mar Junction is attributed to the heavy traffic flow at the early morning hour due to persons travelling to Belize City for work and school. It was also observed that the duration of high noise level lasted for almost the entire 10 minutes sampled due to bottle necks caused by speed bumps, before and after the junction and augmented by the narrow carriage way (due to the newly installed wide median). Drivers also tend to accelerate after clearing the speed bump. Only two residential building are located in this area. The Philip Goldson Airport Junction also had high noise levels, at this early time of the day, but the duration was less. This can be attributed to a free flow of vehicular traffic due to the absence of speed bumps even though the carriage way was narrowed by a median.

The ambient and minimum noise level at the Mile 24.2-Biscayne sampling point was the lowest at 41.5 dBA and 35.3 dBA respectively.

Of the schools areas sampled, three school areas namely Lady of Our Way Primary RC School, Ladyville Technical High School, and Ladyville Evangelical Primary School, the ambient noise level recorded were in the range of 48 dBA to 66.6 dBA, the minimum recorded were 45.2 dBA to 55.6 dBA and the maximum recorded were 81.7 dBA to 94.8 dBA. The observation indicate that Ladyville Technical High School also had a long duration of high noise level which can be attributed to the frequent passenger school buses stopping to unload students and taking off only to immediately slow down to cross a speed bump. The Ladyville Evangelical School noise level was also prolonged as it lies between three busy road intersections (Ladyville, Lords Bank and Lake Gardens).

During construction, the main sources of noise emissions are likely to include the operation of heavy machinery along the highway ROW; vehicle movements to and from the ROW and construction camps and material storage areas; and noise associated from the operation of temporary generators and water pumps used for draining water. The ambient noise levels, which are constant in nature, will increase and will be comparatively higher during the construction phase of the Philip Goldson Highway. Trucks, tractors, and heavy machinery like excavators also generate noise levels beyond tolerable limits. The noise levels at a construction site operation ranges from 96 to 125 dBA. These are above the limits of 75 dBA prescribed by WHO for daytime industrial areas. Exposure for longer periods to 75 dBA levels of noise is likely to affect the ear diaphragms of the workers if the use of Personal Protection Equipment (PPE) is not made mandatory (Chauhan, 2010). Table 6.5 below compares the various noise levels associated with various activities and construction equipment.

6.6.1.2 Residential and School Area Noise

Along Section 1 (Vista del Mar Junction to Burrell Boom Junction) is the most populated area The noise could also be a nuisance to the community especially from the Vista del Mar Junction to the Lake Garden Junction, the most populated area of the highway along Sections 1 of the project area.

There are six schools along the highway in the project area and the road construction impact is considered small to medium in magnitude. Small for Tubal High School, Guadalupe Primary RC School, and Pancotto Primary School since they are situated in the less populated area of the project area and little or no traffic bottleneck occurs. However, medium for Lady of Our Way Primary RC School, Ladyville Technical High School and Ladyville Evangelical Primary School, since they are located in the most populated area of the project area and each school have speed bumps nearby causing traffic bottle necks during peak hours. The exception to all of this will be the continuous exposure to noise pollution of the construction workers.

Table 6.5: Comparative Noise levels.		
Source of Sound	**Distance from Source (m)**	**Sound Pressure Level Decibels (dBA)**
Ambient and Standard Noise Levels		
Ambient noise level		**40**
Normal conversation face to face	**1**	**40 -60**
EPA-maximum to protect against hearing loss		**70**
WHO Maximum –Industrial Work Place **Less than for bedroom for good night rest** **Less than for classroom teaching**		**75** **30** **35**
IFC-EHSG (based on WHO 1999) (noise levels measured out of doors) One Hour LAeq (dBA)	**Day** **07:00-22:00**	**Night** **22:00-07:00**
Residential; Institutional; Educational (For acceptable indoor noise levels for residential, institutional, and educational settings refer to Guidelines for Community Noise, World Health Organization (WHO), 1999.)	**55**	**45**
Industrial; Commercial	**70**	**70**
Construction Noise Levels	**Distance from Source (m)**	**Sound Pressure Level Decibels (dB)**
Air Compressor	15	81
Backhoe	15	80
Chainsaw	1	110
Compactor	15	82
Compactor (Plate)	15	101
Concrete Mixer	15	85
Concrete Vibrator	15	76
Crane Mobile	15	83
Dozer	15	85
Generator	15	81
Grader	15	85
Jack Hammer	15	88
Loader	15	85
Paver	15	89
Pile Driver (Impact)	15	101
Pump	15	76
Rail Saw (Steel-Stone)	15	90
Rock Drill	15	98
Roller	15	74
Saw	15	76
Scraper	15	89
Shovel	15	82
Tractor without cab	15	120
Traffic (Heavy Equipment)	10	90
Traffic (Heavy Traffic)	15	80-89
Traffic (motorcycle/ATV)	15	96-100
Traffic (Passenger car at 65 mph)	10	77
Truck (Concrete Pump)	15	82
Truck (Dump)	15	88
Truck (Pickup)	15	75

6.6.1.3 Effects of Noise on wildlife

The greatest difficulty in summarizing the effect of road noise on wildlife is the fact that very few studies have directly addressed the impact of noise from roads (i.e. the background sound that accompanies varying volumes of traffic), (FHWA, 2014). Livestock and pets are also harmed by noise, as are animals in the wild. Noise can also disturb wildlife feeding and breeding. Noise pollution disrupts animals' navigation instincts and makes it difficult for them to be aware of predators. Night singing of normally diurnal birds, particularly in urban environments, is a well-established observation (Fuller, Warren, and Gaston, 2007).

Since the immediate surroundings of the project area are considered "disturbed" due to the pre-existing highway constructed between 1982 and 1983 and subsequent road improvements, any additional impact from noise on wildlife is assessed as small and the general mitigation measures prescribed for noise pollutions can address the negative impacts to wildlife. Notwithstanding this, if clearing of debris of the Mexico Creek, Black Creek and Mussel Creek is to be conducted, impacts from noise on wildlife is assessed as medium to high (See Section 1.10.5).

6.6.2 Noise Attenuation and Mitigation

Noise abatement is a big challenge for any transportation agencies. Noise is an important factor to be considered when it comes to developing, upgrading and maintaining national highway networks. Noise abatement measures in developing or upgrading national highways uses significant financial resources (Bendtsen, 2009).

It is predicted that the average working day will be 8 hours, thus noise pollution from the construction sites and material transportation will be concentrated during this period. The level of background noise documented for critical areas along the project highway will be used as baseline data to compare against when monitoring for noise levels from construction activities. The construction company should therefore ensure that the construction work plan is well thought out to ensure daylight-working hours and not to exceed 12 working hours, thus limiting daily noise generation to 12 hours. In addition, the contractor will ensure that vehicular transportation, earth moving equipment and hand tools shall be maintained and fitted with mufflers (where appropriate) during operation. Equipment and vehicles shall also be turned off when not in use. Contractor(s) will also carry out regular checks on site equipment to ensure it is running smoothly and efficiently. In quiet zones such as school areas, heavy equipment should avoid having to reverse; therefore reducing the use of reversing beepers when possible. Diesel trucks operators are to avoid Compression Release Engine Braking (Jake Braking) in populated areas and to limit work vehicles to designated access and work site areas. Workers should be asked to work quietly and to avoid speaking too loudly.

The road construction company shall employ best practices in all their activities related noise emissions. These include the proper maintenance of construction equipment and the proper muffling of operating equipment and ensuring that workers wear Personnel Protective Equipment (PPE), (e.g. earplugs to minimize the effect of noise). Consideration should be taken to construct noise barriers, both temporary during construction and permanent during road operation. These barriers walls should be placed between noisy activities at the work site and the schools nearer to the roadside. High noise generating activities, in excess of 75 dBA including ground-disturbing activities, clearing and grubbing, excavation and grading work, installing shoring, blasting, the use of jack hammers, pile driving and rock crushing activities should be restricted to daylight hours, particularly in proximity of existing residential areas – namely within the vicinity of the highway.

Although the use of noise reducing pavements is an option because such pavements are purported to provide a cost effective tool in noise abatement, it is still costly (25% more when compared to the present road surfacing material). For developing countries with limited budget, cost is a limiting fact, therefore the other less expensive noise reduction mitigations can be considered such as speed reduction and noise barriers.

Lastly, it is recommended to establish a good communication strategy to ensure a two way communication process between central government with the local government and public, for residents to take ownership of the project and their expectations to what “noise mitigation” may deliver in terms of noise reductions. Local government efforts could consist of organization and coordination with residents with a view to have new housing along the highway be built as far away as possible from the road side and to encourage leaving any existing vegetation as green noise barriers or if none existing, plant new vegetation. When fences at residential areas are to be constructed or renewed by the owner they can be constructed as noise barriers.

6.7. Vibration

6.7.1 Effects on Human

Belize has *no legal standards that limit exposur*es to vibration. However, the Team felt that exposure to whole-body vibration should be taken into consideration. Whole-body vibration is vibration transmitted to the entire body via the seat or the feet, or both, often through driving or riding in motor vehicles (including tractors and off-road vehicles), through standing on vibrating floors (e.g., while attending to machinery) or using tools (e.g. while operating a jack hammer). Long and constant exposure to whole-body vibration causes back pain. These impacts are mostly limited to the construction workers with negligible impacts to residents along the ROW. However, heavy vibrations can impact roadside structures and in so doing indirectly impact residents along the ROW.

6.7.2 Effects on Surrounding Constructions

Blasting for road material, piling for bridge foundation/stabilization and heavy vehicle traffic along the road may contribute vibration pollution. Buildings and other structures near the road project site will respond to these vibrations, with varying results ranging from no perceptible effects to slight damage at the highest levels. However, ground vibrations from construction activities very rarely reach the levels that can damage structures (WSDOT, 2004) and building vibrations caused by road traffic are not a health and safety concern; they are more a problem of annoyance. Vibrations may be unacceptable to occupants because of annoying physical sensations produced in the human body, interference with activities such as sleep and conversation, rattling of window panes and loose objects, and fear of damage to the building and its contents. Experience has shown that people living in houses are likely to complain if vibration levels are only slightly above the perception threshold, the major concern being fear of damage to the building or its contents. The tolerance level varies widely from person to person and from area to area (Hunaidi, 2000).

6.7.3 Mitigation Measures for Vibration Impacts

Although Belize does not have any standards for vibration pollution, international guidelines were consulted (such as the IFC, and OSHA guidelines) for mitigation measures. Whole-body vibration levels can often be reduced by using vibration isolation and by installing suspension systems between the operator and the vibrating source. In situations, such as those workers using a jackhammer, job rotation, rest periods, and reduction in the intensity and duration of exposure can help reduce the risk of adverse health effects. *All workers will be advised of the potential vibration hazard.*

Although reducing vibrations to an acceptable level could be difficult and expensive (Hunaidi, 2000), construction vibration will be assessed in cases where there is a significant potential for impact from construction activities. Such activities include blasting, pile driving, and drilling or excavation in close proximity to buildings and dwellings, especially those considered in poor structural condition in the Ladyville area (Road Section 1). One clear example is breaking of existing sidewalks with a backhoe for quick removal instead of a jackhammer. This was observed during the rehabilitation of Juliet Soberanis Street, Belize City (Fabro per. obv.). For existing buildings, the most practical remedial measure is road maintenance. For new developments, increasing the distance between buildings and roads, improvement of soil structure, and in ground pile barriers could prove effective.

6.8 Air Pollution: Dust and Emissions

6.8.1 Impacts of Air Pollution

Long-term exposure to high levels of fine particles in the air contributes to a range of health hazards, including respiratory diseases, lung cancer, and heart disease, resulting in 4.2 million deaths annually. Not only does exposure to air pollution affect the health of the world's people, it also carries huge economic costs and represents a drag on development, particularly for low and middle-income countries and vulnerable segments of the population such as children and the elderly (Brauer, et al. 2016). According to the World Health Organization, most of these deaths occurred in low- and middle-income countries.

Quarrying, and its associated activities of excavation, and transportation, and road construction activities have the potential to significantly, adversely affect air quality. The release and dispersion of dust will occur as a result of earth moving operations during site preparation and the transportation of material, movement of heavy construction equipment and traffic. In addition, the operation of heavy machinery will adversely affect air quality through the emission of air pollutants beside the dispersion of dust (Figure 6.21). The effect of construction–related, dust development and air pollution will be of short duration and localized.

All material pits identified are secluded and removed from human dwellings. Therefore, only workers, flora, and fauna in the area would be affected with the exposure to fine dust. In addition, impacts will be limited to the transportation of materials.

Figure 6.21: Heavy equipment bellowing dark exhaust at a material storage site at Philip Goldson Highway (Airport Road Section).

During the dry season, invariably greater dust pollution does occur making it necessary for greater monitoring and personal protection. However, during the rainy season, dust may not be a problem

During the construction phase, the worksite will see the removal and replacement of and filling with road materials. These tasks along with the vehicular traffic associated with them, invariably will cause dust and emissions pollution with the possibility of effecting both humans and flora and fauna.

Air pollution through emissions occurs with the operation of the construction equipment and vehicles. Issues of concern are with the generation of smoke, which will be monitored as suspended particulate matter and chemical emissions such as carbon monoxide, VOCs, SOx and NOx forming smog, which is detrimental to human health impacting more profoundly individuals with respiratory ailments. The impacts from these emissions will be primarily localized and are not predicted to significantly increase the baseline measurements, which were all below detectable limits for all locations. The individuals that would be more directly impacted by this issue are the road construction workers. Table 6.6 below provides the standards set by GOB:

Table 6.6: Regulation 6 Concentration of Air Contaminant.

	Concentration in micro grams per meter cube			
	SPM	SO_2	CO	NO_x
A. Industrial and mixed Use	500	120	5000	120
B. Residential and Rural	200	80	2000	80
C. Sensitive	100	30	1000	30

6.8.2 Air pollution Mitigation Measures

The Department of the Environment, through the Pollution Regulations, has developed mechanisms to monitor and control air and noise pollution. These Regulations prohibits the releases into the environment of contaminants, unless done so with a permit issued by the Department of the Environment and at acceptable levels of contaminants from certain installations.

The regulation states that no person shall cause or permit a building or its appurtenances, open area, **or road or alley to be used, constituted, repaired, altered,** or demolished without taking reasonable precautions to prevent particulate matter from becoming airborne. It requires that dust and other types of particulates be kept to a minimum by such measures as wetting-down, covering, landscaping, paving, treating, detouring or by other reasonable means.

The regulation further states that "no person shall cause or permit the extracting, crushing, screening, handling or conveyance of materials or other operations likely to give rise to airborne dust without taking reasonable precautions, by means of spray bars or wetting agents, to prevent particulate matter from becoming airborne." The regulation also prevents any person from discharging into the atmosphere any contaminant from a gasoline or diesel engine in excess of the quantity specified by the Minister for a motor vehicle operating under normal conditions.

To mitigate against the occupational hazards associated with the generation of dust and emissions, workers will be required to use appropriate PPEs (such as dust -mask). In addition, dust suppression measures will need to be employed to reduce the negative effect these could also have on resident population.

Concerning communities, the level, and thus significance of such impact can be reduced by avoiding haulage of material through residential areas. Where this cannot be avoided, another effective mitigation measure would be to require contractors to regularly water the haul routes in sensitive sections during dry periods.

The impact of air and dust pollution can best be minimized at source by proper maintenance and hauling of construction equipment and by providing appropriate protective working gear (masks, goggles etc.) as required. The protective gear or PPE will also be given to the workers at the quarry since suspended particles will prevail as a result of material extraction, especially during the dry season.

Contractors will need to apply water or other dust suppressants measures. Other preventative measures are fencing off, placing barriers to slow down traffic, or preventing entry to third parties at construction areas (quarries). To avoid unnecessary emissions, contractors will adopt the practice of shutting off equipment whenever they are not in use. They will also ensure that their vehicle fleet and construction equipment are serviced on a scheduled basis to maintain good operational standards. If purchasing new equipment for the project, ensure that these have factory installed emission control devices.

Other general mitigation measures that will be used during construction phase to avoid the impact of air pollution include:

- Utilization of methods and devices that control, prevent or minimize the discharge of contaminants to air, including smoke, dust or soil, including appropriate storage of potentially ‘dusty’ material.
- Avoid burning of materials, particularly in proximity to residential areas (for example the nearby communities).
- Use dust suppressants along with the application of water to control dust pollution.
- Limit speed around construction zone and place barriers to slow down traffic.

- Shut down equipment when not in use and maintain vehicles and heavy equipment in good operating conditions.
- Plan Construction Camp site properly for the placement of equipment and construction storage materials. No work camp should be located adjacent to a water body.
- Dust causing activities and storage of sand will be located away from sensitive areas and downstream of prevailing winds. Enclose stockpiles or keep them securely sheeted. Avoid the use of long-term stockpiles. Keep stockpiles or mounds away from the site boundary, watercourses and surface drains.
- Ensure that all loads entering and leaving site are covered and that vehicles and heavy equipment are in good operational conditions.
- Erect effective barriers around dusty activities near schools and other sensitive areas.

6.9 DRM and Climate Change

6.9.1 Overview: Risks, Hazards Vulnerability and Impacts

6.9.1.1 Risks

Risk is the potential damage that could arise as a result of the occurrence of a hazard with a given degree of uncertainty. Risk is the probability of occurrence of a hazard.

There is also a need to distinguish between *risk* and *hazard*. A *hazard* is a source of danger, while *risk* involves the likelihood of a hazard developing into some adverse occurrence that may cause loss, injury, or some other form of damage. *Risk* may also be defined as:

Risk = Hazard x Probability of occurrence

It should be noted that the consequences of *risk* may be contained if safeguards are put in place. However, hazards cannot be reduced to zero unless the hazard itself is removed.

6.9.1.2 Hazards

Hazards are potentially damaging phenomena, whether natural or man-induced.

Belize is located in an area prone to natural hazards. Foremost among these is the annual occurrence of North Atlantic tropical cyclones and hurricanes that reach the north western Caribbean or develop over the NW Caribbean area itself. The records also show that Belize is prone to eastern Pacific tropical cyclones that traverse northern Central America and impact the country directly or indirectly. Associated hazards include catastrophic winds, storm surges, torrential rains, flash floods/inundations, and tornadoes. Secondary hazards include but not limited to source water contamination, increased incidence of water-borne diseases, increased water stressed on road surfaces and bridges, etc.

Secondly, Belize is bordered by three Central American countries that are prone to volcanic eruptions, earthquakes, tsunami, and mudslides. Even though, historically, Belize has not been impacted directly in a major way by these latter occurrences, it has experienced secondary impacts (NEMO, 2010). A thorough understanding of these phenomena, their intensities, frequency of occurrence and likely impacts are paramount in reducing Belize's vulnerability to these hazards.

6.9.2 Risk Analysis and Risk Assessment

Risk analysis allows for an evaluation of what *hazard* can occur, the likelihood of its occurrence (Probability of occurrence) and the consequences of occurrence.

Risk assessment takes this one-step further to address the issue of <u>the importance of these consequences</u>, if they do occur. As can be observed in Figure 6.22, Risk Assessment takes into consideration the likelihood or probability of the hazards occurring and the consequences or impacts. The outcome of the risks may range from very low or insignificant, moderate (minor), High (significant), very high (major risks) to extreme (or severe). Extreme or severe risk category would probability be prohibitively too costly to mitigate and could jeopardize project implementation.

Based on these definitions, it can be seen that ***risk analysis*** may be carried out in an objective manner, while ***risk assessment*** is much more subjective and should include public policymakers. It is also necessary to introduce the term ***risk management***

Likelihood What is the chance of the risk occuring?	Consequence How severe could the outcome be if the risk even occur?				
	1 Insignificant	2 Minor	3 Significant	4 Major	5 Severe
5 Almost Certain	5 Medium	10 High	15 Very High	20 Extreme	25 Extreme
4 Likely	4 Medium	8 Medium	12 High	16 Very High	20 Extreme
3 Moderate	3 Low	6 Medium	9 Medium	12 High	15 Very High
2 Unlikely	2 Very Low	4 Low	6 Medium	8 Medium	10 High
1 Rare	1 Very Low	2 Very Low	3 Low	4 Medium	5 Medium

Figure 6.22: Risk Assessment Matrix. (Source: Caribbean Community Secretariat, 2003).

Risk Management is the process of implementation of actions required to quantify, mitigate and control risk. Risk Management is closely related to the concept of "safeguards" according to the NEMO (2010) Report.

In summary, the ***risk analysis*** and ***assessment*** phases require the interaction of the scientific analysts with public policymakers. The scientific analyst provides the required information and put the risk analysis in context. It is imperative that the policymakers understand fully the nature of the risks and the cost implications of alternative remedial courses of action.

Another term that must be introduced is that of ***Vulnerability*. This is defined as: *the proportion (as a % or as an index from 0 to 1) of what could be damaged (human life, property, etc.) in a given place in the case of occurrence of a given natural phenomenon or hazard.***

In Disaster Risk Management (DRM), several criteria can be used to determine levels of vulnerability. These may include but are not restricted to: population density and annual growth rates, Human Development Indicators set against long-term urban growth rates, and real adjusted GDP per inhabitant set against illiteracy percentages, or set against child mortality rates. From these indicators, population density and growth rates provide an initial baseline assessment of a country's vulnerability, on the basis that countries with higher population densities are more vulnerable. Another major vulnerability criterion is poverty, which is useful in characterizing the sectors of a society that are most vulnerable to disasters. Housing and infrastructure in disaster-prone area increases a country's vulnerability. For Belize, an evaluation of the vulnerability of individual villages or communities has been facilitated through a review of available infrastructure, as well as the ability of the community to respond to natural disasters (CAPRA Study - GOB/NEMO, 2010).

Vulnerability data compared with natural hazards information can be used to define potential ***risk levels***. Risks may be classified as High (significant), very high (major risks) to extreme (or severe). As indicated earlier, extreme or severe risk category would probability be prohibitively too costly to mitigate and could jeopardize project implementation.

6.9.3 General Hazards of the Study Area

Table 1.7 below is a matrix of hydrometeorological – geophysical and anthropogenic-related hazards that affect Belize. The major hydrometeorological hazards that can impact the PGH project site are: Tropical cyclones and hurricane related hazards such as torrential rains, coastal floods and inundations (pluvial and riverine floods), destructive winds, storm surge and tornadoes; droughts, heat waves and wildfires.

Geophysical hazards

These may include earthquakes and tsunamis.

Man-made Hazards

Man-made hazards that can impact the Philip Goldson Highway rehabilitation project zone include:

- Dam Break
- Chemical Fires and Spills
- Oil Spills
- Road Traffic accidents and
- Aircraft crash (rare, but have happened in the area).

The risk of these man-made hazards increases along the principal highways, with the transportation of fuel, aviation fuel, and LPG. Hazardous substances and material, which enter Belize from the western and northern border frequently, are transported via the PGH to their final destination within Belize or elsewhere.

6.9.4 Hazard Assessment

6.9.4.1 Risk Index

From the foregoing hazard evaluation, and applying the Hazards Risk Index, the risk indexes were determined according to the hazard's likelihood of occurrence, and the severity of the consequences or impacts as they pose to the PGH infrastructure rehabilitation and communities in the zone of influence. The result of this evaluation is summarized in Table 6.7 below.

Table 6.7: Hazards Risk Index.

Major Hazards	Likelihood	Consequence	Risk Index
Tropical Cyclones & Hurricane	Almost Certain (5)	Severe (5)	**25** ***Extreme***
Pluvial floods, Inundation & Storm Surge	Likely (4)	Major (4)	**16** ***Extreme***
Dam Break	Rare (1)	Severe (5)	**5** ***Medium***
Wild Fires	Almost certain (5)	Significant (3)	**15** ***Very High***
Heat Waves	Likely (4)	Significant (3)	**12** ***High***
Earthquakes	Moderate (3)	Minor (3)	**9** ***Medium***
Traffic accidents	Likely (4)	Major (4)	**16** ***Extreme***
Oil Spills	Moderate (3)	Significant (3)	**9** ***Medium***
Explosion (Road Construction & mining)	Likely (4)	Significant (3)	**12** ***High***
Chemical Fires	Likely (4)	Minor (2)	**8** ***Medium***
Air Transport Accidents	Rare (1)	Severe (5)	**5** ***Medium***

6.9.4.2 Evaluation of Impacts Associated with Hazards

Impacts, either negative or positive, caused by natural or man-made hazards on communities or infrastructure are evaluated through ***risk analysis*** and ***risk assessment*** that determine the consequences and importance of the impacts and hence the intensity of the hazards (Table 6.8).

Table 6.8: Natural and Man-made Hazards and Impacts along the PGH (Miles 8.5-24.5).

Major Hazards	Potential Impacts
Tropical Cyclones & Hurricane	Damage / demolish housing, road infrastructure, commercial and household assets and crops/livestock; degrade forested areas; disrupts manufacturing, commerce, transportation and utilities; loss of life and property.
Coastal Floods and Inundation	Loss of life of people and livestock, destroy crops and degrade infrastructure including roads & highways; increased sedimentation to the marine environment.
Dam Break	Possible Maximum Flood for worst-case scenario. Rare and extreme event (1 in 100 Years). Catastrophic impact downstream on communities and infrastructure in flood plain. Short- lived in upper/mid watershed, longer time of concentration in the lower watershed.
Bush Fires	Health hazard. Loss of assets. Land degradation; decreases visibility along ROW of the PGH, burns non-metal pre-fabricated culverts
Heat Waves	Major Health hazard. Loss of livestock
Oil Spills	Pollution of water source around spill site.
Explosion (Road construction & mining)	Loss of life and property
Chemical Fires	Loss of life and property. contamination of air and water resources
Road Traffic Accidents	Loss of life, life-threatening injuries, loss of property. Disruption of traffic on the highway
Air Transport Accidents	Rare event but probability increases with increase air traffic at the Philip Goldson International Airport. Mass-casualty and loss of property, disruption of road traffic, localize fires.

6.9.5 Natural Hazards and Their Impacts

6.9.5.1 Tropical Cyclones

The network of roads and bridges in Belize is significantly impacted by hurricanes and recurrent floods. The Philip Goldson Highway that connects the northern border region and northern districts to the rest of the country is no exception. The under-developed and dilapidated state of infrastructure, especially in the transport sector, heightens the country's vulnerability to natural hazards. In addition, inadequate road maintenance, coupled with under designed road alignments, are contributing factors to both high internal freight costs and undesirably high road fatality rates (MOW/SIF, 2015).

The past 20 years or so has seen tropical storms and hurricanes regularly making landfall along the coast of Belize with significant, cumulative negative impacts to the productive sectors and the sustainable development of the country.

The climatology for the North Atlantic Hurricane basin shows a cyclical trend in periods of high and low hurricane activity in the Basin. Figure 1.22 shows NOAA's seasonal Accumulated Cyclone Energy (ACE) since 1950. It highlights the recent surge of ACE in the Basin, which started in 1995 and began phasing out after 2012. The previous period of high ACE was from 1950 to 1969. Hence, there is an 18-years cycle of high and low hurricane activity in the North Atlantic Basin. This high ACE periodic cycle will *very likely* be shortened in the projected warmer climatic conditions of the 21st century. ACE is calculated by summing the squares of the 6-hourly maximum sustained wind speed in knots (kt) for all periods while the system is at least tropical storm strength. Pink, yellow, blue shadings in Figure 6.23 correspond to NOAA's classification for *above*, *near* and *below-normal* seasons, respectively. The 165% threshold (green line) for a hyperactive season is indicated. Vertical brown lines separate high- and low-activity eras.

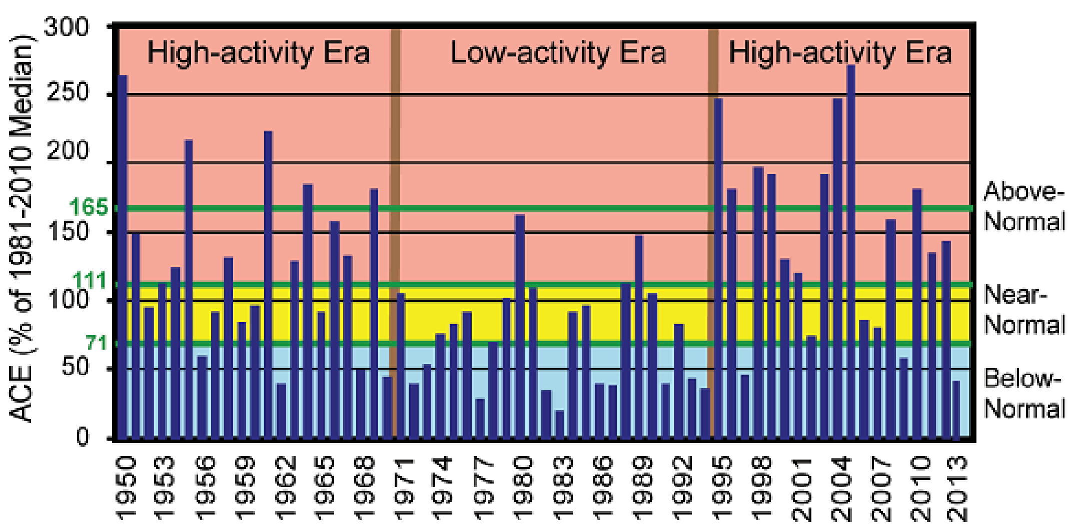


Figure 6.23: NOAA's Accumulated Cyclone Energy (ACE) index expressed as percent of the 1981-2010 median value.

A total of eight (8) tropical cyclones directly or indirectly impacted Belize during the recent, tropical cyclone *High-activity Era*. From 2010 to 2016 tropical cyclone activity seemed to have been on the declined, but Belize continued to be impacted by several weaker but costly systems such as Hurricane Richard (October 2010), Mathew (September 2010) and Hurricane Earl (August 2016), in addition to a string of tropical disturbances.

Meanwhile, another analysis from NOAA show an increasing trend from 15 to 22% in the percentage of Category (Cat) 4 and Category 5 hurricane for the period 1985-2005 for the North Atlantic Basin (Figure 6.24). In short, it is very likely that over the next few decades, tropical cyclone frequency, intensity, and spatial distribution globally, and in individual basins, will vary from year to-year and decade-to-decade (SPM-WG I, IPCC, 2013). Recent research has shown that we are experiencing more storms with higher wind speeds, and these storms will be more destructive, last longer and make landfall more frequently than in the past. Because this phenomenon is strongly associated with warmer sea surface temperatures, it is reasonable to suggest a strong correlation between the increase in storm intensity and climate change are linked.

Climate change and climate variability are projected to accentuate this cycle; not necessarily increasing the number of tropical disturbances and tropical cyclones per season, but increasing the frequency of major hurricanes, that is, more Cat III or stronger storms per season (IPCC, 2007). The IPCC Fourth Assessment Report in the Summary for policymakers (SPM) Group II contribution states: *Since the IPCC Third Assessment, confidence has increased that some weather events and extremes will become more frequent, more widespread and/or more intense during the 21st century* (IPCC, 2007).

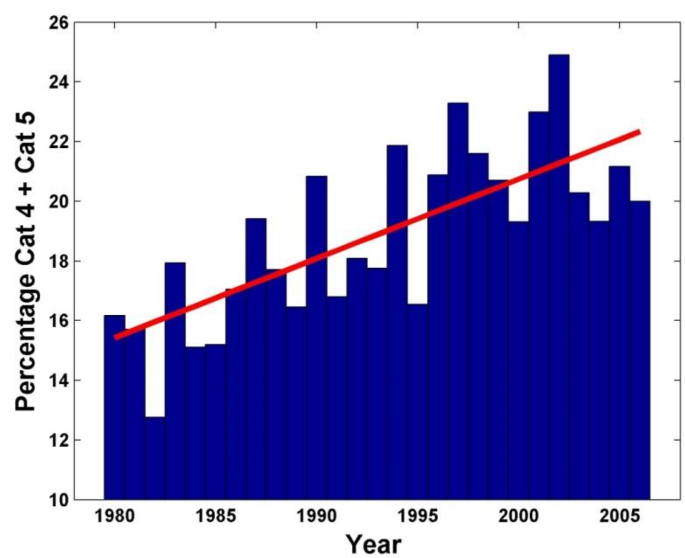


Figure 6.24: NOAA's Estimate of Percent Increase in Cat 4 and Cat 5 Hurricanes in the North Atlantic.

Figure 6.23 shows the National Oceanic and Atmospheric Administration's estimate of percent increase in Cat 4 and Cat 5 hurricanes in the North Atlantic (NOAA, 2015).

The proposed rehabilitated Philip Goldson Highway from Vista del Mar junction to Gardenia Village will remain vulnerable to hurricane-related hazards during the projected 20-year infrastructure lifespan. Consequently, a series of mitigation measures are being recommended to increase the resiliency of the rehabilitated road to the negative impacts of hurricane- related hazards.

6.9.5.1.1 An Overview of Historic Hurricanes and Return Periods

A review of the North Atlantic hurricane annals for the past 107 years reveals that Belize sits snugly along the re-curving track of the infamous Cape Verde Islands hurricanes, and along the pathway of the western Caribbean storms that so often ravaged Central America with deadly force, and end up exhausting their latent energy over some part of country, before regaining their strength once they are over the warmer waters of the south-western Gulf of Mexico.

Updated analysis based on hurricane tracking maps and reports since 2000, showed that nine (9) hurricanes and four (4) tropical storms affected the country of Belize. Ten (10) of these tropical cyclones impacted the northern Cays and northern and central zones of the country, with torrential rainfall, storm surge and sustained, hurricane force winds, resulting in extensive beach erosions, coastal and inland flooding, infrastructural damage, degradation of forests and agricultural assets, and the loss of human life. Figure 6.25 is a map showing the trajectories of these tropical cyclones.

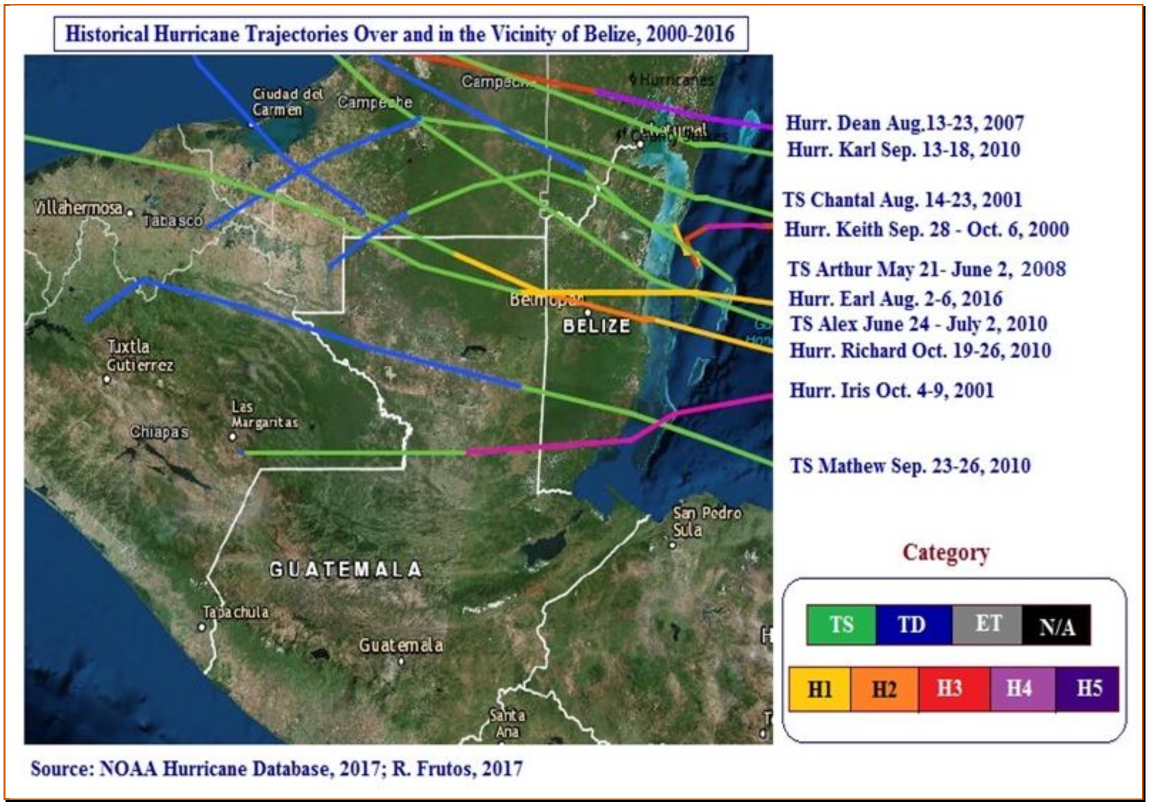


Figure 6.25: Tracks of land falling tropical cyclones over Belize (2000-2016).

Table 6.9 is a list of the recent hurricanes that significantly impacted the PGH zone of influence. Foremost among these were Hurricane Keith of September – October 2000, Hurricane Richard of October 2010, and Earl of August 2016.

Table 6.9: Historic Tropical Cyclones that Impacted the PGH Zone of Influence.

Hurricane	CAT	Landfall Date	Max Wind at Landfall	Impacts and Damage USD
Hattie	4	31 Oct. 1961	150 mph	Landfall was just south of Belize City, generating a 15 feet storm surge. Destroyed forests and generated extreme flood conditions. Large acreage bushfire scars.
Greta	3	19 Sep. 1978	110 mph	Made landfall near Dangriga Town; produced torrential rainfall in the Maya Mountains and northern Belize. Losses US $25 million.
Hurricane Mitch	5	1998		Dangerous Hurricane Mitch threaten Belize, powerful wave actions degraded beach fronts, but Mitch moved southward across the Bay Islands & Honduras Serious coral bleaching and die-off on reefs. The rains associated with Mitch generated flooding in the lower Belize River watershed, and large-scale evacuation of families from the Cayes and the coastal zone, including Belize City. Approximately 30,000 persons evacuated.
Hurricane	4	29 Sep. – 2	135 mph	Powerful Hurricane Keith impacted San Pedro, Ambergris

Keith		Oct., 2000		with a storm surge of 4 – 5 feet, and caused extensive beach erosion. Torrential rainfall accompanying the hurricane provoked record-setting floods in the Belize River Valley and PGH project site. Keith set the record for the highest 24-hour rainfall of 482 mm at the PGIA Met Station; now considered a 1:100 year event.
Tropical Storm Arthur		26 May – 2 June 2010		Formed just offshore central Belize from the remnants of Pacific TS Alma. Produce flooding over central and northern Belize.
Tropical Depression 16		October 2010		Remnants of TD 16 generated torrential rainfall and extensive floods in the Belize River Valley and the project zone that inundated several sections of the PGH.
Richard	1	Oct. 24,2010	90 mph	Cat 1 Hurricane Richard tracked over southern Turneffe Atoll and made landfall near Gales Points. Gale force winds damage much of the vegetation along the storm path. Broken and fallen tress cluttered the stream channels, and the dry matter became fuel for widespread bush fire in the very active 2011 Fire Season.
Earl	1	August 3, 2016	90 mph	Hurricane Earl made landfall over Southern Belize district on August 3, producing a storm surge of 2 – 3 feet and widespread beach erosion and localized coastal flooding.

(Source: CRRE, 2013; NMS, 2016; NOAA, 2016)

The frequency of tropical storms and categories of hurricanes have varied over the past 118 years (Table 6.10).

Table 6.10: Frequency of land-falling Tropical Cyclones in Belize (GOB, 2007).

Intensity	Events	Greater Interval Analysis
Tropical Storm	32	1 in 4.42 years
Category 1	7	1 in 12 years
Category 2	6	1 in 15.5 years
Category 3	3	1 in 34.5 years
Category 4	2	1 in 40 years
Category 5	2	1 in 52 years

Three Cat 3 hurricanes, 2 Cat 4 hurricanes, 2 Cat 5 hurricanes affected Belize during the period (1889-2008). Since June 2000, five tropical cyclones have affected Belize. Notably one of the Cat 3 (Keith), one of the Cat 4 (Iris) and one of the Cat 5 (Dean) hurricanes that have affected the country were in this decade.

6.9.5.1.2 Return Periods

In summary, the return period for a category 5 hurricane is about once every fifty years. However, a category five hurricane is possible in the western Caribbean in any season, particularly during the 10-15-year cycle of seasonal ACE upsurge, as was the case between 1995-2010, and 1960–1979

6.9.5.1.3 Potential Impacts on the PGH and Zone of Influence

Tropical Storm and Hurricane-force winds topple trees and adjacent infrastructures that clutter the roadway and disrupt traffic access and rescue operations. Risks to life and property in communities in the zone of influence heighten during storm events, and sections of the road infrastructure can be severely degraded or undermined. The impacts can be summarized as follows:

- Flooding of low areas of the PGH: Ladyville, Lord's Bank; Burrell Boom Road near junction with PGH; Double Run junction area; Mile 17 Sandhill Village, and sections from Mexico Creek Bridge northward to Gardenia.
- Floods damage road infrastructure because of the energetic runoff and the limited capacity of stream channels to contain excessive flow, especially at bridge crossings.
- Road shoulder scouring and degradation of road surface pavement in submerged sections of the road and collapse of old culverts and subsidence.
- Increased siltation and debris clog channels, culverts, bridge underpass, which is exacerbated by un-sustainable land use and poor maintenance.
- Hurricane-force winds, gusts, and tornadic wind pockets destroy campsite buildings; topple chemical containers causing spills and fires.
- Disruption of traffic on the road resulting from fallen trees, debris and flowing floodwaters, which may last for a few hours to a couple days.
- Destroy utilities in the zone of influence and downed power line and fallen trees, disrupting road accessibility.
- Debris including boulders, solid waste etc. strewn across road from flood action.
- Increased chance road accidents and fatalities.
- Loss of life and property in communities.

- Loss of livelihood in communities and disruption of agriculture production, tourism industry, and commerce.

6.9.5.2 Coastal Flooding and Storm Surge

Extreme hydro-meteorological events in the form of flash floods, inundations, and high-winds associated with the passage of tropical cyclones and hurricanes have direct and indirect impacts on the PGH. Indirect impacts that exacerbate the hurricane related hazards are land use changes in the sub-basins and micro catchments of the Greater Belize River Basin (GBRB), that changes the hydrology of the catchments. This results in increased runoff, increased siltation, and clogging of channels. In addition, installation of undersize and skewed culverts, and poor drainage or lack thereof at critical spots along the highway and access roads, impedes the free flow of storm water. The absence of coordinated maintenance of stream channels, culvert outlets, and discharge channel outflow adds to the problem.

Inundations in the major watersheds of Belize are generally associated with tropical cyclones and occasionally with deep instability connected with the interaction of cold air mass and the warm, moist tropical air mass in the western Caribbean and northern Central America. Several major flood events that stand out are:

- The 1979 September – November rain events that generated widespread floods in the lower reaches of the GBRB in the Belize District. Rainfall at the Philip Goldson International Airport and in Belize indicated that the total rainfall recorded increased from 19.4 cm in September to 58.4 cm in October, then to 38.1 cm in November and 37.1 cm in December. This accumulated rainfall resulted in extensive flooding in the Belize River Valley and the project zone during late October and November. The PGH between Biscayne and Belize City was inundated in several sections. Many communities in the Belize River Valley and the Old Northern Highway were inundated. The Belize River crested above its natural bank and channelled across the PGH at the curve in the river near the Old Sewing factory site (Mile 8.25), and in the Mexico Creek Bridge area. The floodwaters flowing across the highway severely damaged the pavement as it headed towards the sea. The rainfall during the latter part of the period was associated with a late-season tropical disturbance interacting with a cold front that generated torrential rainfall over central Belize.

- In August 1995, the San Ignacio area was flooded. During this event, the BECOL run-of-river dam at Mollejon was breached at its sides. This flooding was as a result of a strong tropical disturbance. The flood wave reached the lower Belize River watershed several days later, resulting in extensive flooding in the PGH project zone.
- Later in October 1995, Hurricane Roxanne generated extensive flood in the middle and lower reaches of the Rio Hondo in the western Orange Walk District and NW Corozal District. The flooding also affected the lower Belize River catchment. Five villages had to be evacuated as a consequence of this event.
- In September 2000, powerful Cat 4, Hurricane Keith impacted San Pedro, Ambergris with a storm surge of 4 – 5 feet, and caused extensive beach erosion. Torrential rainfall accompanying the hurricane provoke record-setting floods in the Belize River Valley and PGH project site

- During late October and early November, 2008 extensive floods in the Mopan River sub-basin generated by the heavy runoff associated with the passage of Tropical Depression #16 across southern and central Peten, Guatemala, affected the flood plain areas of the GBRB. The floodwaters reached some 4 to 5 feet at some sections of the George Price Highway in Benque Viejo and Succotz Village in the Cayo District. A statistical analysis for extreme flood events at Benque using the Gumbel EV1 distribution resulted in a Return Period of 33 years for the 2008 flood event in the Mopan, Macal, and Belize River. The TD 16 flood reach the lower Belize River catchment six days later, flooding extensive areas of the Belize River Valley and sections of Double Run, Lord's Bank and Ladyville. The PGH in the Mexico Creek Bridge – Gardenia section was inundated for several days, as the wet lands in the area were filled to maximum capacity, and spill across the highway. Similar flooding severely impacted the section of the PGH from just south of Haulover Bridge to Belama Phase IV. Transit along the highway was severely disrupted, and the surface pavement extensively degraded.

Figure 6.26 is a map showing the main sections of the Philip Goldson Highway from Vista del Mar Junction to Gardenia that are prone to annual floods of the PGH, including the Mexico Creek Bridge – Gardenia area, Burrell Boom Road,

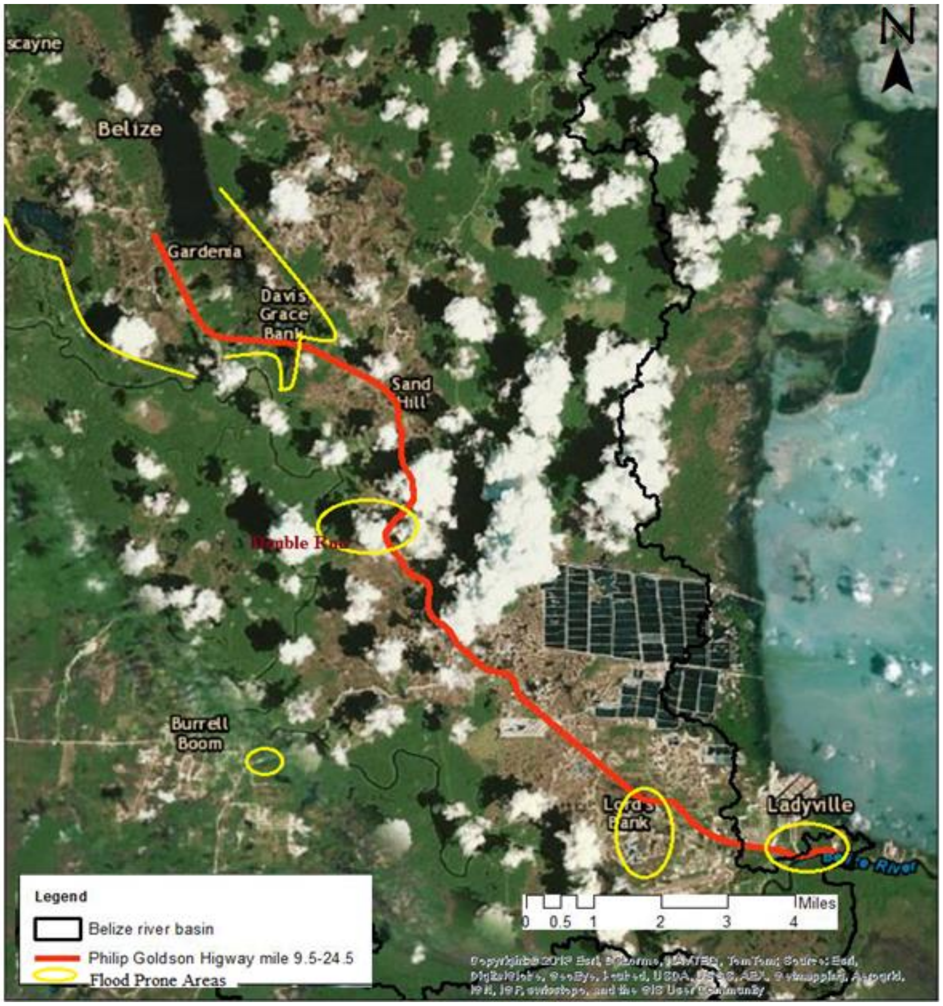


Figure 6.26: Flood-prone section of the PGH between Vista del Mar and Gardenia (Source: Philip Goldson Highway Project Site, TOR Feasibility Study, MOW, 2015).

Due to the low elevation of the coastal plain, sea water levels influence river stage in the lower Belize River. In their flood and storm surge analysis, Golder Associates Ltd. (2017) estimated that sea level rise for the 20-year life span of the PGH rehabilitation project is projected to be 0.30 m. According to Golder Associates Ltd. (2017), predicted storm surges for 1:2 year and 1:100 year return periods will range from 0.20 m to 6.50 m, which is in the range of the TAOS storm surge model results (OAS, 1995).

Using historic flood data for Belize, Golder Associates Ltd. (2017) conducted statistical analysis for flood flows, which were adjusted for potential climate change effects. The results showed that the 1:2 year and 1:100-year Belize river flood flows were in the range of 313 m^3/s and 1,092 m^3/s, respectively.

Hydrological and hydraulics analysis were also carried out by Golder Associates Ltd. (2017), for 42 culverts crossing along the PGH sections slated for rehabilitation. Flood flows were modelled for each of the crossings and current, installed hydraulic capacity determined. Culvert upgrades recommendations were made to increase the hydraulic capacity and adjusting the road cross-section to make the road less vulnerable to overtopping.

6.9.5.2.1 Storm Surge

Hazards associated with land falling hurricanes along the coast of Belize include torrential rainfall, tornadoes, storm surge, and coastal flooding. The TAOS (The Arbiter Of Storms) storm surge model (OAS, 1995) projected a 1.8 meters surge along the coast just north of Belize City for a Cat 1 hurricane, 5.2 meters for a Cat 2 hurricane, 7.2 meters for a Cat 4 hurricane and about 7.6 meters for a Cat 5 hurricane.

Figure 6.27 shows a map of the storm surge result for a Category V hurricane crossing the central Belize District. The coastal zone east of the PGH project sector would be inundated by a storm surge in excess of 18 feet of water in a Cat 5 hurricane, bearing in mind that such an extreme event has a return period of 50 to 100 years. The constraint of high-resolution LiDAR mapping limits the evaluation of the spatial extent of such a storm surge flooding up the lower Belize River and the PGH rehabilitation project zone, during an extreme rainfall event.

However, the effect of a storm surge generated by a Cat 4 or Cat 5 hurricane along the river would be in the form of 'back flow', which would raise water levels as far upstream as Grace Bank, which in turn would exacerbate the riverine flow if it was already at flood stage before the land falling hurricane.

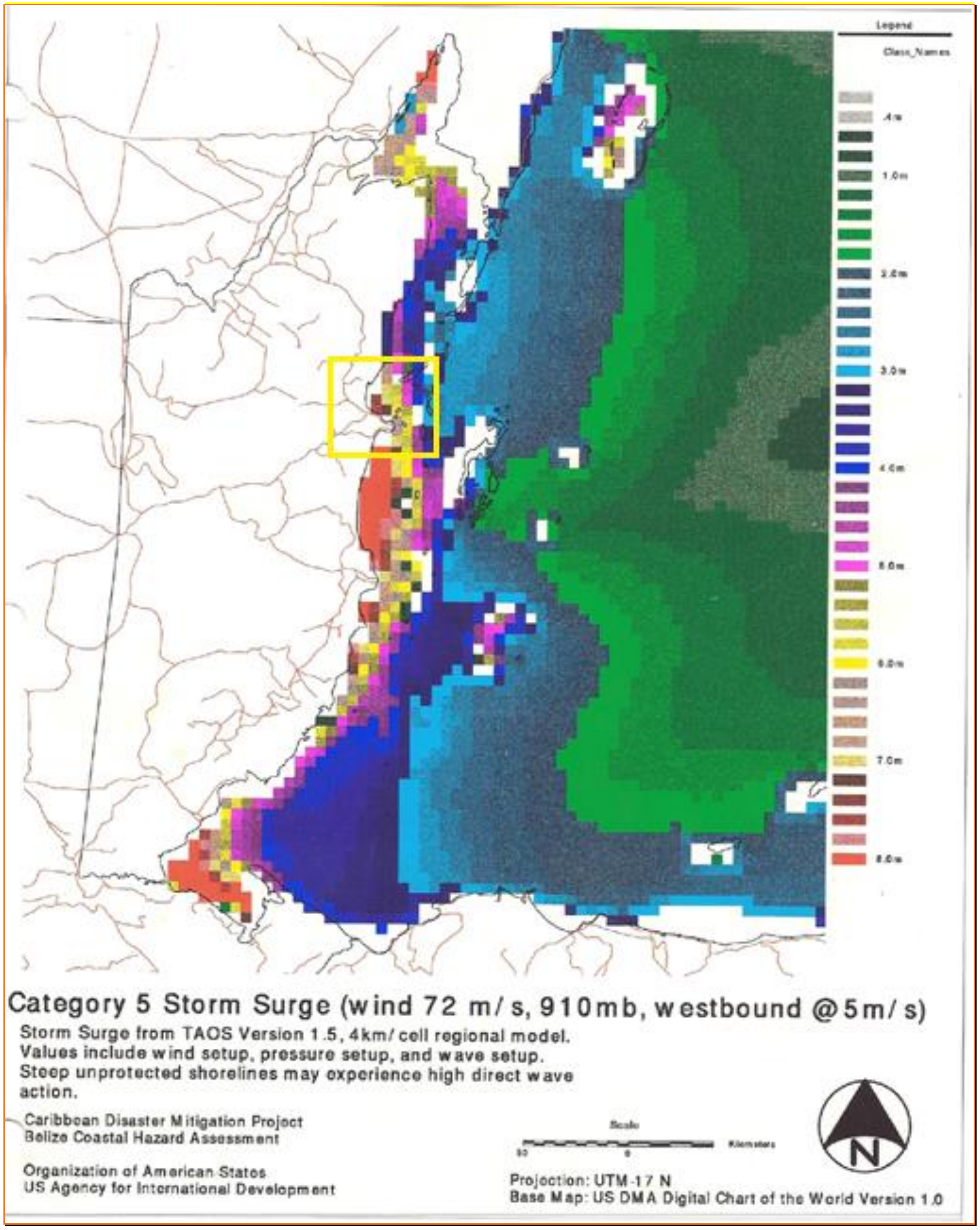


Figure 6.27: TAOS Storm Surge Model Result for a Cat 5 Hurricane.

Golder Associates Ltd. (2017) simulated water levels along the PGH using current and future river flows with storm surge (adjusting for climate change). The results showed that in the worst-case scenario under current water flows in the Belize River and a storm surge, areas in the first 6 km of the southern limit of the highway project zone including most of the section through Ladyville, Burrell Boom Junction and 5 km around the north of Mexico Creek Bridge would become inundated for a 1:25 year return period event (See Green Line on Graph in Figure 6.28 of plot of PGH elevation (crest) and flood levels above mean sea level (msl)).

For the future, worst-case scenario (around 2040s), about 12 km of the southern limit of the highway would become inundated, including areas in Ladyville-Lord's Bank-Burrell Boom Junction, Double Run and a 6-km stretch around and north of Mexico Creek – Gardenia Village (See Green line in the illustrated graph in Figure 6.29). Raising of the highway and upgrading the drainage and flood-relief canals would not help in such an event. The road would become impassable for some time, and evacuation from Belize City, Ladyville, and the Cayes during an emergency would have to be completed well in advance.

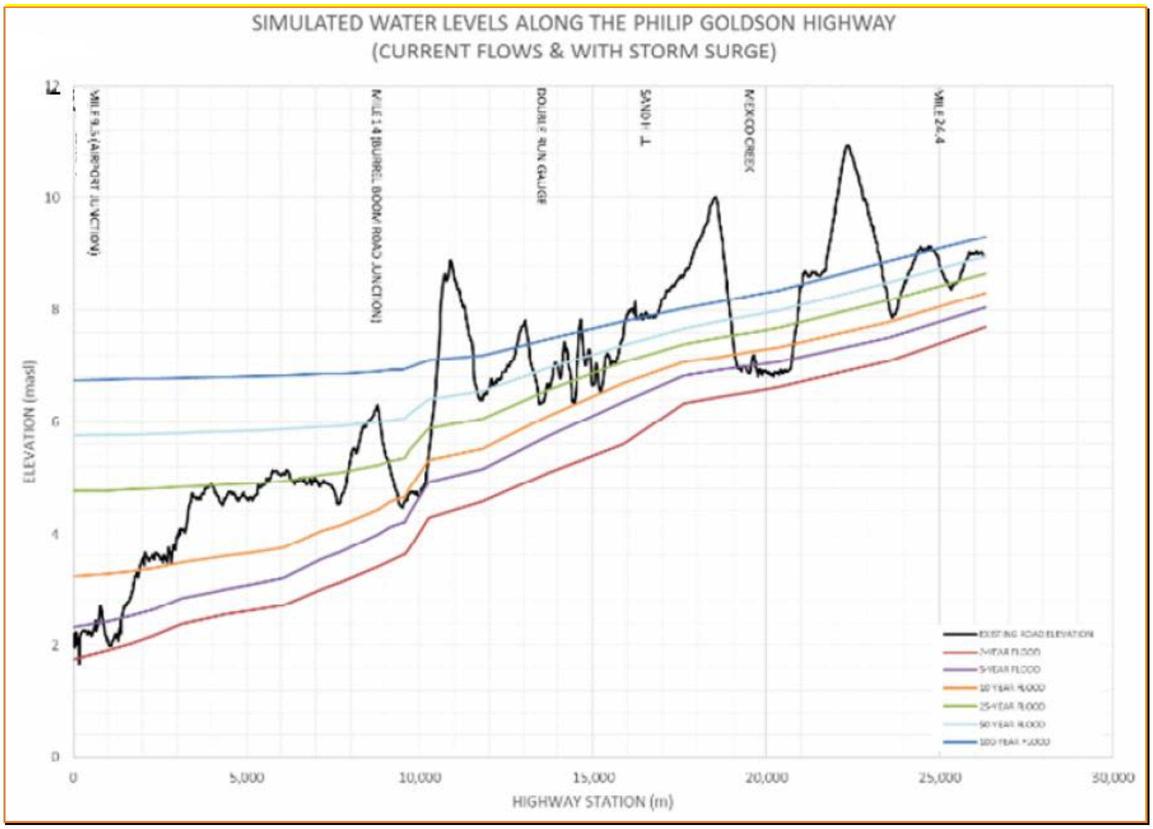


Figure 6.28: Simulated Water levels on the PGH using Current Flows with Storm Surge. (Source: Golder Associates Ltd. 2017).

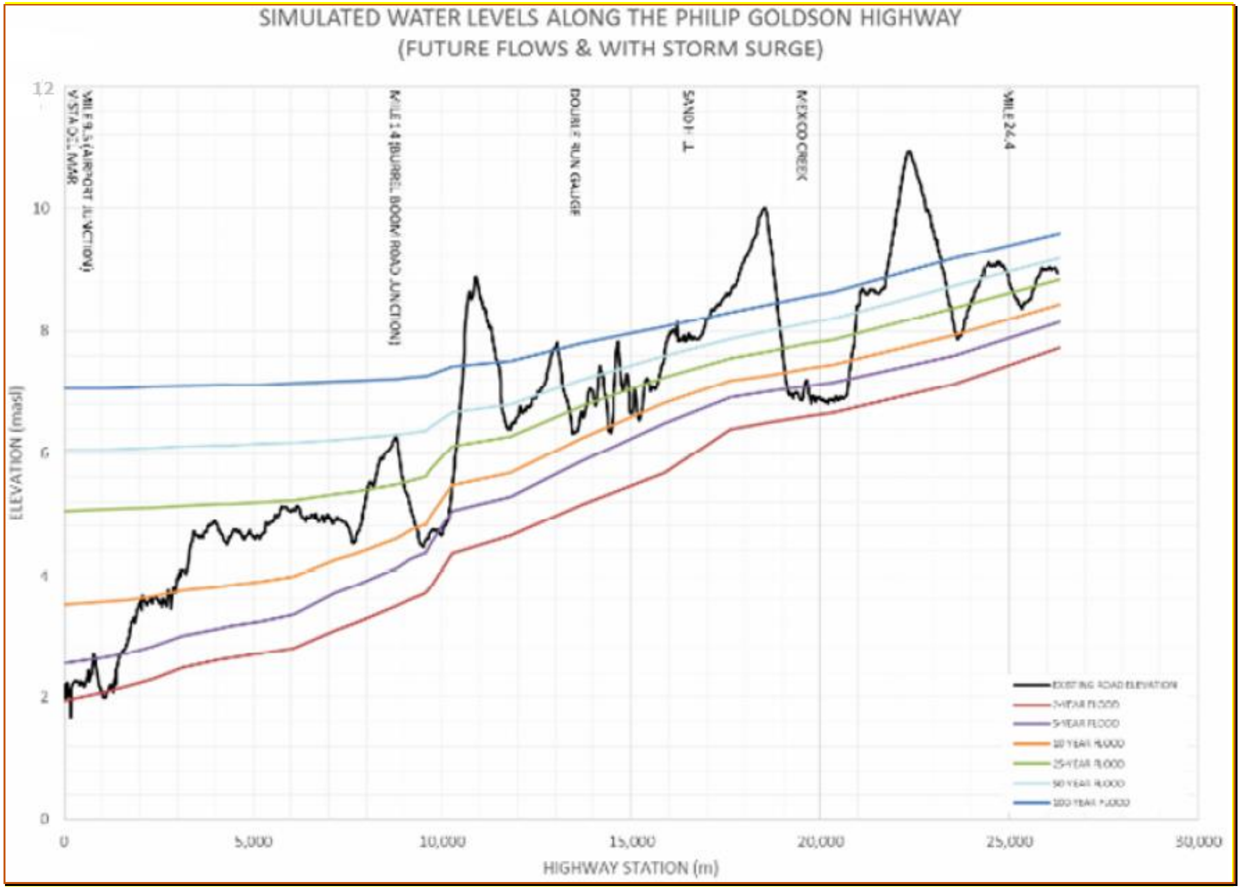


Figure 6.29: Simulated Water levels on the PGH under Future Flows with Storm Surge. (Source: Golder Associates Ltd. 2017).

Figure 6.27 and Figure 6.28 above, are results of the hydraulic model simulation graphs of the water levels on sections of the Philip Goldson Highway for current and future river flow regimes with storm surge, respectively. The black line is the compressed trace of the current road crest (or elevation) and the red, purple, green, light blue and dark blue trace are flood water levels for 2 year, 5 year, 10 year, 25 year, 50 year and 100 year return periods, respectively.

6.9.5.2.2 Limitations

The Golder indicated that the available hydrometeorological data sets limited the study of the complex nature of rainfall distribution, hydrology, and the hydraulics realities across Belize. Hence, many results of the study have a degree of uncertainty and the simulation simplifies the complex nature of the physical environment.

Recommendation proposed is that additional data (rainfall, river flows, and river and sea level statistics) be collected and further hydrology and hydraulics studies be conducted to support future highway design.

6.9.5.2.3 Mitigation for Tropical Cyclone and Storm Surge

The following measures are recommended to reduce the risks to the rehabilitated PGH posed by future tropical cyclones and flooding.

Mainstreaming risk reduction during highway upgrade and maintenance:

- Choice of the material for road re-construction to withstand the adverse conditions of aggressive rainfall, pluvial floods, inundation, and extreme heat is "*hot mixed*". It is more durable than the "*chip seal*" option and less costly than the "*concrete*" option.
- At sections where lifting the existing road to avoid flash floods and inundation is impractical or may adversely affect the local hydrology; it is recommended that such sections be re-constructed with concrete, which is much more resistant to flowing or standing water. This is recommended for the flood prone area around and 3 km from Mexico Creek Bridge and central Ladyville.
- As far as possible, all culverts that are recommended for replacement be of a standard size and design (i.e. 42-inch diameter, ferro-concrete) and inlets – outlets properly designed and constructed to allow for the free flow of runoff. Avoid culverts of material that are flammable.
- Longitudinal drains should be designed, constructed, and maintained to minimize ponding and overflow onto the highway or inundate private property. Drains should connect to permanent outflow systems such as the Vista del Mar canal, setting ponds near the Belize River or reserved wet lands.
- All sections recommended for road re-alignment should have the proper drainage to avoid damming or obstructing surface runoff from either side of the road.
- MOW is recommended to request the establishment of a 'C*ost Center*' in the annual budget for river and stream channel/drainage maintenance and upkeep. It is recommended that this activity be carried out jointly with sister departments such as Forestry, Agriculture and Fisheries, and also the local community, so that the latter can have ownership in the upkeep and maintenance of village culverts, drainages and stream channels in the zone of influence of the PGH.

- The Road Maintenance ‘cost centre’ should also have allocation for trimming and clearing tall trees and vegetation along the ROW of the upgraded PGH.
- Approach to the Mexico Creek Bridge and the deck of bridge should be at least one meter above the maximum flood stage.
- The road design recommends raising the road around and north of Mexico Creek Bridge. This may result in the construction of a new bridge for the Mexico Creek crossing. Structures should be put in place to minimize impacts on the creek ecosystem and at completion, return the streambed to its natural level.
- Concrete Box culverts of adequate dimensions should be placed at designated spots along the rehabilitated PGH to serve as animal crossings. The aim is to reduce wild animal kill and avoid road accidents.
- MOW should liaise closely with the Agriculture Department and Forestry to promote sustainable land use practices for farmers and other stakeholders in the project zone. This should help reduce siltation and damming of the river and creek channels that exacerbates flooding downstream.

Other Flood Mitigation Measures

- A recommendation to help minimized the impacts of floods on communities and infrastructure in the country and to improve the monitoring of floods in Belize is to automate the river stage monitoring stations at critical sites in the upper and middle reaches of the major watersheds. The timely data will inform the preparation and dissemination of timely and reliable flood warnings. Over the past two years, automatic gauge sensors powered with solar technology have been installed at several critical river sites around the country, but more of these are needed to improve the hydrological monitoring network.
- Also, the Hydrological Department should utilized the numerical model rainfall projections and the NMS radar products, as tools to aid in flood forecasting, and the same should be disseminated on a timely basis as the need arises.
- Another recommendation to reduce the impacts of future floods in Belize is to improve flood mapping in all watersheds using modern technology such as LiDAR generated high-resolution digital elevation maps (DEM), at 1 m to 0.5 m resolution. By over-laying

LiDAR DEM with flood stage maps using the ArcGIS software, the hydrologist can produce higher resolution flood maps that can be used in planning, development, and disaster risk management. Such maps can help planners and engineers determine the actions needed for road upgrade at critical sections of the road network, and to identify alternative routes that can be rehabilitated as evacuation routes during an emergency.

6.9.5.3 Wild Fires, Droughts and Heat Waves

Droughts and heat waves are projected to increase in intensity during the 21st century as the warming of the climate system continues (IPCC, 2007). In Belize, this trend will favour higher incidence of bush fires, particularly during the height of the dry season.

> ***"Brushfires have been sparking all across the country; the Fire Department says it is caused by the dry spell. While there is nothing unusual about the "bushfires", residents of Lord's Bank had a close call on Sunday when a fire spread dangerously close to many houses. The smoke billowed across the area as fire fighters battled to contain the blaze…"*** **Channel Five News, 22 April, 2013**

6.9.5.3.1 Wild fires

Forest and bush fire requires dry fuel and suitable climatic conditions for the fires to propagate. The Fire Season in Belize runs from February 15 until May 31. Historically, active fire seasons usually follow previous years, land falling hurricanes that often leave a trail of destroyed forest debris in their wake as they plough inland. Figure 6.30 is a wild fire risk map of Northern Belize. The PGH project zone is a 'high risk' wild fire zone according to the Wild Fire Risk map.

The very busy Fire Season 2011, (see Fire Season Map, Figure 6.31), particularly along the swath of damaged broadleaf forest ecosystems caused by Hurricane Richard as it tracked through central Belize on October 24, 2010, was an example of extensive secondary or cumulative impacts on the natural ecosystems following land-falling tropical cyclones in Belize. Meerman (2011) indicated that the total area burned during the 2011 Fire Season was about 86,400 ha (213,500 acres), mostly across central Belize, where Hurricane Richard did the most damage to the natural vegetative cover some five months earlier.

Bushfires and coastal pine ridge savannah fires are common during the Fire Season each year, and may affect not only the operational phase of the PGH project, but even during the construction phase.

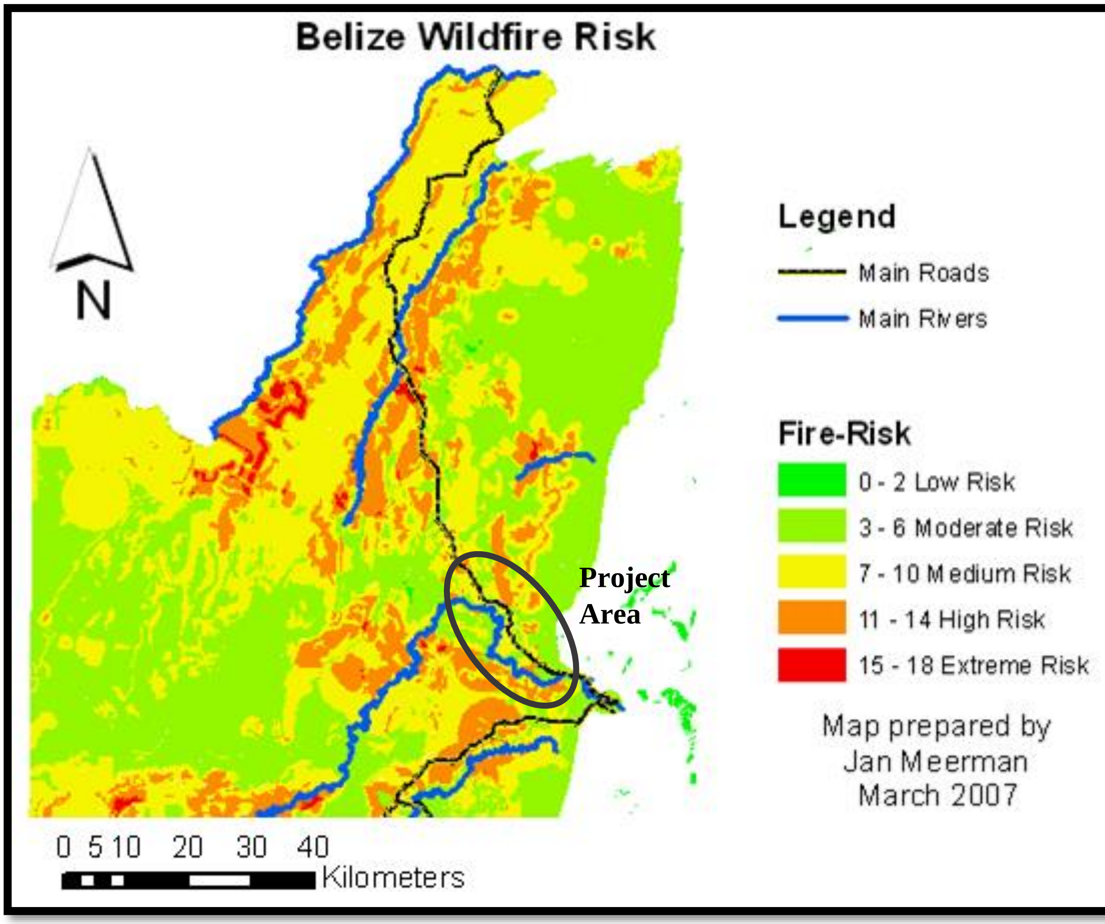


Figure 6.30: Wild Fire Risk Map of Northern Belize.

6.9.5.3.2 Analysis of Droughts and Heat Waves Related to Bush Fires

Droughts and heat waves are hydro-meteorological phenomena that the IPCC (2007) indicates will increase in frequency and intensity because of climate change, especially in tropical regions.

Droughts also develop regionally because of blocking pattern (i.e. an *omega block*) in the atmospheric circulation that keeps persistent subsidence over the region for an extended period. Hence, vertical motion of air is suppressed, and moisture uplift and cloud/rainstorms formation are restricted. Years of warm phase of El Nino Southern Oscillation (ENSO) in the eastern Pacific are closely connected with droughts and related heat waves in Central America and Belize. The ENSO phenomenon is characterized by sustained sea surface temperature anomalies of more than 0.5˚C in the eastern Pacific Ocean, which trigger flooding, drought, and other disturbances throughout much of the world, including Central America and Belize. It is likely that warmer climatic condition will enhance ENSO, and intensify its impact. El Niño and La Niña episodes typically last nine to twelve months, but some prolonged events may last for years.

While their frequency can be quite irregular, El Niño and La Niña events occur on average every two to seven years (NOAA, 2016). Typically, El Niño occurs more frequently than La Niña.

Some historical droughts years across Belize, including the PGH project zone of influence include 1974-75; 1986-87; 1997-1998; 2000-2005; and 2015-16.

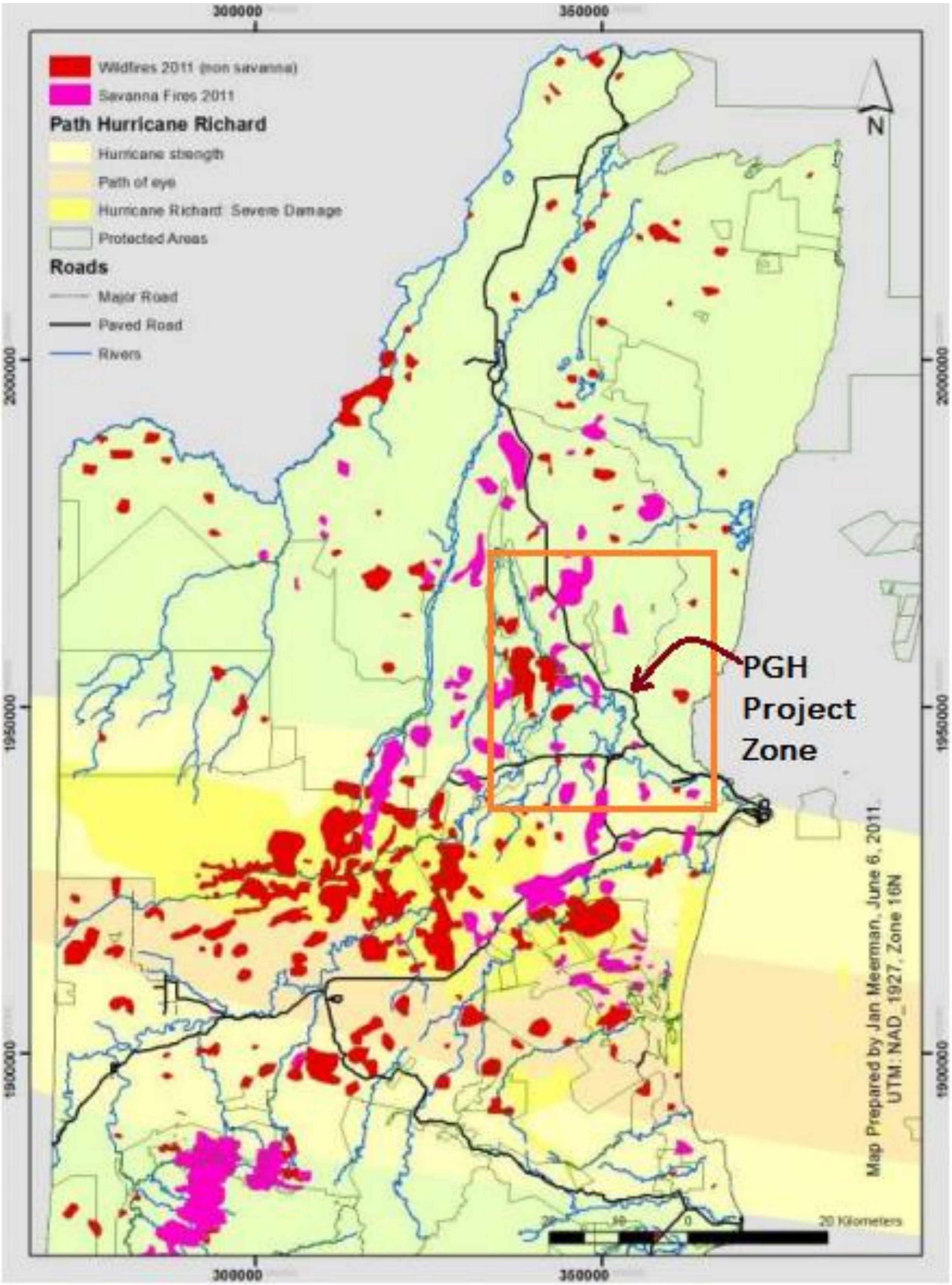


Figure 6.31: Wildfires detected in Northern Belize in the 2011 Fire Season.

6.9.5.3.3 Return Periods

The frequency of droughts and heat waves in western Belize and the Philip Goldson project zone is correlated to the ENSO cycle and regional atmospheric circulation patterns. Climate change is projected to influence the intensity of ENSO events and increase the frequency of droughts in Central America and Belize in the medium and long term (IPCC, 2007).

6.9.5.3.4 Potential Impacts

The impacts of forest fires on road construction and the rehabilitated road are the following:

a. May disrupt road construction. Work crew may be requested to help fight the fire.
b. Smoke inhalation and intense heat can result in heat strokes, which can be deadly for individuals and road users in the area.
c. Reduced visibility on the road due to thick smoke.
d. May results in loss of costly equipment if these are not removed from danger zone.
e. Traffic on the PGH may likely be disrupted if blaze is just off the road.
f. May destroy culverts made of petroleum-based products.
g. Roads users may become trapped with little options but to wait until fire burns out.

6.9.5.3.5 Mitigation Measures

- Work Camps are to have signs posted regarding risks of wildfires and encourage no smoking.
- Workstations and work camps should have fire extinguishers readily available.
- Culvert should be made of concrete or other fire-resistant material in savannah areas.
- Contactors must be brief on action to be taken in the event of major forest fire near road construction sites and the environmental/ health and safety liaison should alert the authorities.

6.9.6 Man Made Hazards

Man-made hazards that can impact the PGH rehabilitation project zone include:

- Chalillo Dam Break
- Accidents involving the transport and handling of hazardous goods.
- Road and Air Transport Accidents

The risks of these man-made hazards increases along the principal highways and secondary roads accesses such as the Burrell Boom Road, with the transportation of fuels, bitumen to construction activities, and the increase of visitors exiting the Philip Goldson Airport and the northern road artery from the border with Mexico. Hazardous substances and material enter Belize from the western and northern border and the Belize City port on a daily basis, and are transported via the PGH to their final destination within Belize, or elsewhere to neighbouring countries.

Accidents involving hazardous material and fuel to work sites have the potential for the greatest consequences because of the hydrology of the area and special care is required when handling vehicles transporting these materials on a very busy highway. These accidents could severely contaminate surface water used as a source of potable water and would require special measures to contain and clean up. In addition, traffic on the road can be obstructed for a longer period of time than a normal traffic accident.

The use of explosive material during road rehabilitation works poses a hazard mainly to the work crew. In addition, mining for minerals and rocks (e.g. granite) may also necessitate the use of explosive material.

6.9.6.1 Dam Break – Possible Maximum Flood

The Belize Electric Company Limited (BECOL) Upper Macal River Hydroelectric Facilities at Vaca, Mollejon, and Chalillo are now fully operational and generate about 55% of Belize's energy needs. In accordance with the April 5, 2002 Environmental Compliance Plan (ECP), BECOL, in collaboration with NEMO and other stakeholders, developed and operationalize a Dam Safety *Emergency Preparedness Plan* (EPP), specifically under the Chalillo Hydroelectric Project. According to BECOL, the dam is designed to meet and exceed all standards for dam safety, however the Plan is developed in the interest of public safety should an unlikely dam break emergency scenario arise.

The EPP is designed to deal with any problem experienced with the integrity of the Chalillo Dam structure. As indicated earlier, the EPP was formulated in conjunction with relevant agencies responsible for activities during natural disasters in the area of public safety. Figure 6.32 shows the Chalillo dam spilling after heavy rainfall in the area.

Figure 6.32: Chalillo dam spilling after period of heavy rainfall.

A schematic of BECOL's Emergency Preparedness Plan (EPP), a Flowchart of BECOL's Dam Break Notification Protocol, and a NEMO Dam Failure public awareness leaflet are contained in Annex XVI.

While the dam is designed not to fail, a monitoring plan for recording changes in dam structure and hydrology is in place, and compliments the response measures outlined in the EPP should an emergency related to a dam failure occurs.

The dam break study and assessment done in preparation of the Chalillo EPP indicated that the *Probable Maximum Flood* (PMF) for the Macal River would generate a higher river flow than a dam break (120 million m^3), under normal weather conditions.

The worst-case scenario with the greatest extent of flood is projected for a dam beak at full capacity during a major storm event affecting Belize, and is outlined in red on the model PMF maps (Annex XVII).

A worst-case scenario dam failure will very likely be catastrophic for communities in the upper and middle Belize River watershed. The energy and height of the flood wave will diminish in the flat and extended flood plain of the lower Belize River watershed, but the time of concentration of a TD 16-type flood will be longer (i.e. days to weeks).

Although the probability of such an event is small throughout the projected 50-year lifespan of the Chalillo dam, the possibility of such an event still hangs over the head of all communities and interests downstream of the dam. The Dam Failure modelling simulation done for the Belize River watershed area was projected up to Banana Bank-Never Delay area, with projected flood maps for these areas. However, the modelling was not projected down to the Belize River Valley and the lower Belize River sub-watershed.

The worst-case scenario of a dam failure can be comparable to an inland tsunami, with a highly energetic flood wave sweeping through the confined channel of the upper Macal River on to the Hawksworth Bridge in about 2 hours, then spreading across the floodplain down to Roaring Creek in about 7 hours from the initial break point at Chalillo. The Model PMF flood maps provide estimate time of the arrival of the maximum flood wave. The time factor for the moving flood wave is crucial in the evacuation plan for all communities in the projected PMP flood area. Hence, loss of life and property can be mitigated only through a quick and well-rehearsed respond coordinated by NEMO, DEMO-Cayo, BECOL, and citizen's response groups in the flood risk zone.

Mitigation measures to reduce the impacts of a failure of the Chalillo Dam on the PGH are limited to the durability and water-resistance of the road surfacing material used during re-construction, firmness of the road foundation and adequately designed and constructed culverts, and public awareness campaigns on the hazards and response to a dam failure flood.

Recommended Specific Mitigation Actions

- The Project Management Unit, Ministry of Works, and Contractors will be kept informed of all Press Releases and Public Notices from BECOL/NEMO with respect to the status of the Chalillo Dam and reservoir, especially during extreme rainfall events.

- The Project Management Unit through the Ministry of Works will liaise with BECOL and NEMO on updates on the Dam Break Emergency Plan and annual simulations.

- BECOL/NEMO should ensure that Flood Evacuation Route Signs be properly displayed and maintained in all communities.

- Village Flood Plan Maps should be developed and displayed in key public locations.

- The MOW should have a Plan B for alternate traffic routes in those sections of the roads prone to annual floods and a PMF flood event.

- Project Management UNit and MOW/SIF engineers will consider a more durable pavement application for section of road prone to pluvial floods and inundation (e.g. concrete pavement).

6.9.6.2 Road Accidents

The PGH like the George Price Highway that runs west to the Cayo District and the western border, has been the scene of many, major road accidents that have resulted in numerous fatalities. The reasons for the fatal incidents range from drunk or careless drivers, road safety measures, carelessness of other road users (cyclist and pedestrians), and slippery roads during inclement weather conditions. The Transport Department, Police, and other key public and private stakeholders are cognizant of the problem. The Government of Belize through the Transport Department is drafting a National Transport Master Plan to regulate public transportation in Belize and improve road safety. The Transport Department is also implementing and coordinating the Road Safety project, aimed at regulating vehicular transit and road use on the George Price Highway, specifically in the section between Belize City and Belmopan. A reduction in traffic accidents has been observed since the project was implemented some two years ago.

The rehabilitation of the PGH in the Miles 8.5 to Miles 24.5 sections, should greatly improved road safety in its projected 20-year life span and beyond. However, traffic accidents will no doubt reoccur, and mitigation measures should be instituted to reduce fatalities on the road.

6.9.6.2.1 Hazardous Goods Accident

It is hard to estimate the exact probability since the probability of an accident that will affect the road has a wide range of possible scenarios. Thus, the probability of accidents is not calculated but rather just mentioned as a possible hazard.

6.9.6.2.2 Air Transport Accidents

The proximity of the PGH rehabilitation project site to the Philip Goldson International Airport exposes the road and its zone of influence to air transport accidents or mishaps that may result in mass casualties and damage to the highway infrastructure and private property in the area. Although it may be argued that such an event is very remote and has not occurred in the recent past, the risk is still there, and the Civil Aviation Authorities have their contingency plan for such an event in place, and a Fire Service in a state of readiness at all time.

6.9.6.2.3 Potential Impacts

The potential impacts associated with the transportation and handling of hazardous goods are listed below and are likely to happen, especially during construction phase.

a. Loss of human life and assets;
b. Pollution of water and ground;
c. Impacts on biodiversity, and
d. Disruption of traffic on the PGH and the Philip Goldson International Airport road, if the accident is .in the vicinity of the Airport Road junction

6.9.6.2.4 Mitigation Measures

- Public awareness and education of how persons and families must respond during such an emergency.
- Regular mass casualty air transport simulation for first responders such as civil aviation personnel, Fire Service personnel, medical and ambulance personnel, Red Cross, and NEMO (Transport and Evacuation Committee etc.).

- Establish alternate transit detours in the event that the PGH in the project zone (Miles 8.5 to Mile 24.5 % is closed to traffic.

6.9.7 Climate Change

6.9.7.1 Evidence of Climate Change and Climate Model Projections

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

The future climate for Central American-Caribbean sub region will likely be characterised by increasing temperatures and reduced levels of precipitation (UNDP, 2009). The projections have been confirmed through several analyses of climate models. Christensen *et al.* (2007) in a set of climate model simulations based on the A1B scenario for changes in the climate between the baseline period 1980-1999 and 2080-2099, estimated a median temperature increase of 2.0 °C for the Caribbean region and 3.2 °C for Central America. The study projected a median decrease in annual precipitation of 12 % for the Caribbean region and 9% for Central America. The models also projected a 39% increase in extremely dry seasons for the Caribbean and a 33% increase for Central America.

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

6.9.7.2 Climate Change in Belize

Analysis of historic climate records for Belize show evidence of a changing climate (CCCCC, 2014; UNDP, 2009).

a) Temperature

Mean annual temperature has increased by 0.45 °C since 1960, at an average rate of 0.10 °C per decade. The average rate of increase is most rapid in the wet seasons (May, June, July and August, September, October) at 0.14 - 0.15 °C per decade and slower in the dry seasons (November, December, January and February, March, April) at 0.08 - 0.09 °C per decade.

The mean annual temperature is projected to increase by 0.8 to 2.9 °C by the 2060s, and 1.3 to 4.6 degrees by the 2090s. The range of projections by the 2090s under any one emissions scenario is 1.5 – 2 °C. The projected rate of warming is a little more rapid in the wet seasons, May, June, July and August, September, October than the dry seasons November, December, January and February, March, April.

b) Precipitation

Mean annual rainfall over Belize has decreased at an average rate of 3.1 mm per month per decade since 1960, but this trend is not statistically significant. Whilst all seasons appear to have shown decreasing precipitation trends since 1960, only February, March, April has a statistically significant trend.

Projections of mean annual rainfall from different models are broadly consistent in showing decreases in rainfall for Belize. Ensemble median values for almost all seasons and emissions scenarios are negative. Projections vary between -64% and +20% by the 2090s with ensemble median values of -11 to -22%.

Changes in rainfall show the strongest decreasing signal in May, June, July rainfall, at -83 to +22% by 2090s. The proportion of total rainfall that falls in heavy events is projected to decrease in May, June, July, consistent with decreases in total rainfall.

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

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

i) Increased surface ambient and sea surface temperatures;

ii) Sea level rise; and

iii) Increased frequency of more intense hurricanes (Cat 3 or stronger) in hurricane basins around the world (IPCC, 2013).

6.9.7.3 Climate Change in the PGH Project Zone

The climate model: “Providing Regional Climates for Impacts Studies” (PRECIS) is a regional model, which was developed and released by the Hadley Centre of the United Kingdom, with the aim of improving model projections at the regional level via down-scaling of Global Model results, such as the Hadley Center and the ECHAM4 global climate models.

Table 6.11 below shows a summary of the PRECIS-ECHAM4 A2 & B2 model projections of mean surface temperature (°C) and per cent (%) change in rainfall in June-July-August (JJA) for Philip Goldson Airport, Belmopan, Central Farm, and Tower Hill for 2020-25 and 2080-85, relative to the baseline period 1970-2000.

Table 6.11: Model Projections of Temperature and % Change in Rainfall for Philip Goldson Airport, Belmopan and Central Farm.

Station	**Temp Trend 1961-2013**	**PRECIS-Echam4 Projected Temperature Change deg. C**				**Rainfall Trend 1961-2013**	**PRECIS-Echam4 Projected % Change in *JJA* Rainfall**			
	deg. C/decade	**2020-2025**		**2080-2085**		**mm/decade**	**2020-2025**		**2080-2085**	
	± Min/Max/Mean	**A2**	**B2**	**A2**	**B2**	**±**	**A2**	**B2**	**A2**	**B2**
PSWGIA	+ 0.10 °C (Min T) + 0.15 °C (Max T)	1.1	1.3	4.0	2.9	+ 14 mm	-28.3	-24.5	-79.2	-74.0
Belmopan		1.0	1.5	3.5	3.8		-23.2	-19.2	-55.2	-52.5
Central Farm		1.1	1.4	4.2	3.0		-10.3	-2.0	-65.2	-51.0
Tower Hill	- 0.20 °C (Mean T)	0.8	1.3	3.5	2.9	+ 120 mm	-32.6	-26.4	-68.9	-60.4
Mean		**1.1**	**1.4**	**3.9**	**3.2**		**-20.6**	**-15.2**	**-66.5**	**-59.2**

(For Period: 2020-2020 & 2080-2085 relative to 1970-2000). (Source: PRECIS RCM climate projections, CCCCC, Belize 2014; R. Frutos, 2014)

i) **A2** storyline and scenario family: a very heterogeneous world with continuously increasing global population and regionally oriented economic growth that is more fragmented and slower than in other storylines (Business-as-usual scenario).

ii) **B2** storyline and scenario family: a world in which the emphasis is on local solutions to economic, social, and environmental sustainability, with continuously increasing population (lower than A2) and intermediate economic development. (Low emission scenario)

In summary, the regional model projection of surface temperature over coastal Belize will be in the range of 1.1 to 1.3 °C by 2025, and 2.9 to 4.0 °C by mid 2080 (Projections for Philip Goldson Airport). Mean percent change in rainfall from the 1970-2000 climatology for June-July-August is in the range of -24% to -28% by 2025, and -74% to -79% by mid 2080.

The general conclusion is that the warming trends in surface temperatures will continue in the short, medium, and long term, with significant consequence on the hydrological cycle. Rainfall variability projections for the first half of the rainy season (JJA) is for drier conditions.

Repercussions on the Philip Goldson Highway rehabilitation and operation is for more intense but short-lived rainstorms, higher frequency of stronger land-falling hurricanes, increased storm surge effects, and increase in extended periods of droughts and heat waves. Increased extreme hydro-meteorological conditions will likely undermine the road infrastructure, which in turn will require more prudent and timely maintenance. Communities in the zone of influence will also become more vulnerable to the climatic extremes.

Table 6.12 is a summary of the seasonal changes in rainfall projected by the PRECIS regional model. In the short term (2020-2025), the largest variations of rainfall of -28% for the Business-as-usual scenario (A2) are projected for the JJA, followed by -20% variation in DJF season for the Philip Goldson International Airport.

Table 6.12: PRECIS-Echam4 projection of future per cent change in rainfall for Coastal 7 Central Belize.

Precip % Change PRECIS-ECHAM4 A2					Precip % Change PRECIS-ECHAM4 A2			
	DJF2020-25	MAM2020-25	JJA2020-25	SON2020-25	DJF2080-85	MAM 2080-85	JJA2080-85	SON2080-85
PGIA	-20.2	-11.3	-28.3	-13.9	-55.2	-15.1	-79.2	-54.0
Bmp	-23.2	-15.1	-20.5	-7.1	-48.8	-26.2	-55.2	-31.9
CF	-27.2	-6.1	-10.3	-5.4	-49.8	-2.9	-65.2	-36.1
Precip % Change PRECIS-ECHAM4 B2					Precip % Change PRECIS-ECHAM4 B2			
	DJF2020-25	MAM2020-25	JJA2020-25	SON2020-25	DJF2080-85	MAM 2080-85	JJA2080-85	SON2080-85
PGIA	2.2	19.1	-24.5	-35.5	-39.2	-4.2	-74.0	-49.3
Bmp	-4.7	18.1	5.1	-19.2	-30.6	21.8	-52.5	-20.4
CF	10.4	13.0	-2.0	-28.7	-31.5	2.0	-51.0	-41.2

(Source: PRECIS RCM climate projections, CCCCC, Belize 2014)

6.9.7.4 Heightened Risks and Impacts due to Climate Change

Risks and impacts on the proposed Philip Goldson Highway project stemming from climate change include:

- Likely increase in more intense hurricanes making landfall over central Belize, degrading the road infrastructure, and affecting the livelihood of communities in the project zone.
- Higher storm surges, coastline erosion, and coastal flooding likely to increase with land falling tropical cyclones; which will impact the highway foundation, pavement, and other infrastructures.
- Increased incidence of inundations in the lower Belize River watershed, including wetland connectivity from Crooked Tree Lagoon system to Mexico/Jones Lagoon, the Gardenia area, Mexico Creek and the Belize River.
- Increased frequency of intense heat waves;
- Increased incidence of bush fires;
- Increase erosion along road shoulders.

6.9.7.5 Mitigation Actions

- Engineering designs for road rehabilitation, by-passes or alternate routes and bridges, and culverts/drainage must meet AASHTO standards for resilience to extreme hydro-meteorological conditions.

- The Technical Feasibility Study of the PGH project) recommends a 0.3 m increase in mean sea level for the road design (Golder Associates Ltd., 2017).
- MOW Road Maintenance Unit will be strengthened to address Highway infrastructure inspection and maintenance in a timely and effective manner.
- MOW in collaboration with Forest Department, DEMO-Belize District, and communities, will institute a river and stream channel maintenance program for the lower Belize River, Mussel Creek, and Black Creek and Mexico Creek.
- MOW will update its Hurricane Plan and SOP for damage assessment and clearing of the Philip Goldson Highway at the declaration of the Green Phase.
- On-going Public Awareness and Education programs will be conducted for communities in the zone of influence to enhance Knowledge, Awareness, and Perception on Climate Change, the negative impacts of climate change, and response during an emergency.

6.10 Ecological Impacts

All of the wetlands within the PGH project site and those wetlands and lagoons servicing the Belize River Watershed are vital to the watershed community, especially those communities and businesses downstream. Some of these wetlands in the southern part of the project site have been "urbanized" and their flood mitigation value greatly reduced. All of the wetlands have been disconnected by the present highway structure. This increases the value of the Mexico Lagoon/Jones Lagoon and wetland system within the project area, in helping mitigate flood effects to downstream residents. Therefore maintaining hydrological interconnectivity is vital to maintaining both the ecological health of these wetlands and their roll in flood mitigation.

The proposed highway improvement project provides an opportunity to re-establish interconnectivity within this landscape, helping reduce flood impacts to local communities and a major transportation route while at the same time it will attract new development, requiring additional filling of wetland areas, sewage treatment system discharge, storm water discharge, solid waste build-ups, canal/drainage construction, road and driveway construction, and other issues related to urban expansion, unless planning and development restrictions are put into place and strongly enforced.

6.10.1 Ecosystem Loss

i. Road Footprint

As most of the upgrading of the Highway will be done within the existing right of way, and largely mirror the current footprints of both the Highway and the verges with little widening in a few areas, with effective implementation of the Plan, there is scope for there to be negligible loss of any natural ecosystem within the buffer area.

Construction compounds will be needed for the housing of machinery, equipment, and materials, but these will be located on existing cleared land or leased farmland and not require any conversion of natural ecosystems. These should be rehabilitated to former use on completion.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Ecosystem Loss	Increased Road footprint	Minimal	Very Low

ii. Main Drain Footprint

The refurbishing of the existing Vista Del Mar Main Drain as a flood mitigation action, to reduce the duration and extent of flooding in Ladyville, runs for approximately 750m through an area of *tropical evergreen seasonal broad-leaved alluvial forest – occasionally inundated* interspersed with elements of *mixed mangrove scrub* that lies within the urban expansion footprint of Ladyville.

Assuming that the main drain remains as a 5m wide drain, the existing footprint will be affected where over grown vegetation and debris will be removed from the drain in order to restore the drain's full functionality. In addition, refurbishing of the main drain mechanically will cause some additional impacts to this localized area of vegetation. Heavy equipment will require access on both banks of the main drain, resulting in an impact area that is three or four times wider than the actual drain. This area will be de-vegetated, compacted, rutted, and generally modified during cleaning of the main drain and again when the main drain requires maintenance cleaning.

The impacts of habitat loss caused by the restoring of the Vista del Mar Main Drain are therefore assessed as low to medium within the wider landscape, and lying within the Ladyville expansion area.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Ecosystem Loss	Clean up of the Main Drain	Low	Low
Ecosystem loss	By backhoe or other heavy equipment	medium	medium

iii. Quarries

It is anticipated that suitable quarry material will not be available within the buffer area of the Highway upgrade, and that material will therefore have to be transported from the existing quarries -- which already should have their operational standards in place. As there is no need to open any new quarry the impact to the areas ecosystem from material sourcing is assessed as minimal.

6.10.2 Loss of Ecosystem Connectivity

i. Road Footprint: Reduction of Ecosystem Connectivity

Ecosystem connectivity was significantly impaired by the original roadwork in the construction of the Highway. Currently the existing roadbed serves as a dam that separates sections of wetland areas, preventing those wetlands from performing their full ecological services. Ultimately, this leads to the drying out of sections of wetlands where flow has been restricted and flooding of other sections of the landscape during the wet season when water from intensive rains does not have adequate drainage through the roadbed. However, as most of the Highway upgrade will be conducted within the existing right of way and be largely superimposed over the current highway, with very little, if any, lateral realignments, there should be negligible incremental increase in these impacts. There is, however, scope to restore some previously lost connectivity through improved culvert design, and cleaning of excessive material left behind in the active creek bed during the construction of the Mexico Bridge. This will provide reduction of flood impacts to local communities and a major transportation route.

There will be vertical realignment along significant portions of the upgraded Highway to reduce inundation risk during storm flood events. The modest increase in pavement height, however, will not require steep shoulders – so should not have any incremental impact on ecosystem connectivity.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Reduction of Ecosystem Connectivity	Road Footprint	Negligible	Very Low

ii. Main Drain Footprint: Reduction of Ecosystem Connectivity

Careful planning should go into consideration of the necessity of a link canal to drain Ladyville and its surroundings, and canal construction avoided since a 5m main drain already exists within the Ladyville expansion area, this main drain bisects an area that is already surrounded on all four sides by the Highway and urban roads. If the plan is to enhance the area's natural drainage system while avoiding the construction of a canal that links the sea to the Belize River., the **incremental** reduction in ecosystem connectivity will be very low. However, a linking canal could have severe consequences to water abstraction points upstream of the area due to increased salinity. In addition, the canal could increase the area's vulnerability to erosion and possibly undermine the road infrastructure itself and greatly impact the Ladyville Area coastal ecosystem from the flushing out of the large volumes of sediment-loaded fresh water. The reduction of the Belize River flow at this point could also reduce the flow within the Haulover Creek and further reduce the proper flushing of the Belize River mouth.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Ecosystem Connectivity	Excavation of main drain	Very Low	Low

iii. Increased Edge Effect

Confined to the existing right of way and footprint of the Highway, and following the best practice mitigation measures laid out in the Plan, there should be no, or negligible, negative impact on Edge Effect of adjacent natural ecosystems.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Increased Edge Effect	Road Footprint	Zero / Negligible	Very Low

6.10.3 Wildlife

6.10.3.1 Species of Conservation Concern

Of the species of conservation concern identified in the Baseline Assessment, the most vulnerable to potential negative impacts from the upgrading of the Highway are the critically endangered Central American river turtle (hicatee), the endangered yellow-headed parrot, tapir and Yucatan black howler monkey, and the nationally flagged Jabiru stork.

- **Central American River Turtle (Hicatee)**

Severely over-hunted, the critically endangered Central American river turtle, or hicatee, has been extirpated from most of its former range in Mexico and Guatemala and has disappeared from much of its former range in Belize – previously thought to be the last remaining stronghold for this species. Current protective measures in all three countries have been shown to be inadequate and "at recent harvest rates, the species is expected to be driven inevitably to extinction" (IUCN 2017).

Whilst the upgrading of the Philip Goldson Highway is unlikely to have any direct impacts on the hicatee, the recommended removal of debris blocking sections of Mexico Creek, Mussel Creek and Black Creek to improve drainage and reduce the incidence of flooding of surrounding villages has to be done carefully so as to not further impact the few remaining populations of hicatee. This portion of the Belize River watershed, in particular, Black Creek, Mexico Creek, Mussel Creek, has long been recognized as home to perhaps the largest population of hicatees in Belize (Weyer, D., 1994). The dark waters of these creeks have afforded some refuge for the turtles from the extreme impacts of turtle hunting in clear waters (such as the Sibun), enabling the population to persist longer than in other areas. The fallen tree debris and vegetative growth, now scheduled for clearance, has afforded additional and greater protection from hunting pressure by partially obstructing access, making the use of illegal set nets and free-diving difficult. Crucial detailed mitigation actions are presented in the Mitigation Plan, and it is considered imperative that these be fully implemented to avert the possibility / likelihood of the creek restorative works further reducing this critically endangered species from one of its few remaining areas with a potentially viable population.

Target of Impact	Source of Impact	Potential Scale of Impact	Impact Ranking
Central American River Turtle, hicatee	Re-opening of Black Creek, Mexico Creek and Mussel Creek	Local extirpation due to increased access for unsustainable hunting a real possibility, with implications for global population	Very High

- **Yellow-headed parrot**

The endangered yellow-headed parrot has suffered an estimated 90% decline across its range between the mid 1970's and 1994 (IUCN 2017). An estimated 75% of the global population is now thought to occur in Belize, with an estimated current national population of 1,200 birds, but despite efforts towards conservation, the Belizean population has continued to decline. (National Bird Working Group, unpublished report, 2017). Yellow-headed parrots are recorded in the savannahs within the buffer zone of the Highway upgrade, but with severe pressure on nesting sites from uncontrolled anthropogenic fire and nest-robbing/destruction for the illegal pet-trade it is not known whether successful breeding still occurs in this locality.

With good adherence to the mitigation measures developed in the Mitigation Plan, the upgrading of this section of the Highway is unlikely to have any significant impact on the yellow-headed parrots in the surrounding savannahs.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Yellow-headed parrot	Upgrading of Highway	Very Low / Low	Very Low

- **Jabiru stork**

With a huge distributional range stretching from Mexico through Argentina, and a global population thought to number up to 25,000 individuals, the Jabiru stork is not a species of international concern. In Belize however from historical records, for the period 1968 – 1987, of 36 known nesting sites (Barnhill et al., 2005) only 22 were found in 2005 (Figueroa, 2005) –

making the Jabiru one of Belize's rarest breeding birds. With so few known nests, and quite specific nesting requirements (primarily tall trees, with branchless trunks towering over surrounding vegetation), the Jabiru is a species of national pride and concern.

One nest is located approximately 100m southeast of the Grace Bank Road, and only 250m from the Highway. The birds using this nest site are evidently unperturbed by the traffic on the nearby highway, but would presumably be vulnerable to disturbance to the possible use of the Gracie Bank Road for machinery or material storage. The Mitigation Plan therefore calls for the avoidance of use of this road for construction-related activities, so that possible impacts are kept very low.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Jabiru Stork – nesting site	Upgrading of Highway	Very Low / Low	Low

- **Tapir**

The upgrading of the Highway is unlikely to have any significant incremental impact on the tapir population of the area, over and above the impacts of the Highway in its current state, since the re-clearance of Black Creek, Mexico Creek and Mussel Creek - with their riparian vegetation being known preferred habitat and haunts of this endangered species will be limited to the **manual** removal of trees and snags from the water ways to reduce the potential primary impacts such as temporary physical disturbance and displacement of tapirs in the vicinity and damage / loss of their riparian habitat.

Detailed mitigation measures are laid out in the Mitigation Plan to reduce what would otherwise be potentially severe impacts on the tapir population within the buffer area.

Target of Impact	Source of Impact	Potential Scale of Impact	Impact Ranking
Tapirs and tapir habitat	Re-opening of Black Creek, Mexico Creek and Mussel Creek	Low	Low
			Low

- **Yucatan black howler monkey**

Like the tapir, the upgrading of the Highway should have only a minimal impact on the howler monkeys of the area, since the re-clearance of Black Creek, Mexico Creek and Mussel Creek -

with their riparian vegetation being known preferred habitat of this endangered species – will be limited to the **manual** removal of trees and snags from the waterways.

Detailed mitigation measures are laid out in the Mitigation Plan to reduce what would otherwise be potentially significant impacts on the howler monkey population within the buffer area.

Target of Impact	Source of Impact	Potential Scale of Impact	Impact Ranking
Howler monkeys and their habitat	Re-opening of Black Creek, Mexico Creek and Mussel Creek	Low	Low

- Antillean Manatee

Belize's population of between 700 to 1,000 Antillean manatees, an endangered subspecies of the West Indian manatee, is the largest within the Central American sub- population, with the highest national counts occurring around the mouth of the Belize River. Manatees travel up the Belize River and Black Creek as far as Northern Lagoon. The greatest threat to Belize's manatees is boat traffic, with a total of 42 confirmed deaths in 2015, the majority from boat strikes. The clearance of hurricane debris from Black Creek will impact manatees in two ways, firstly through physical disturbance during the work which will cause a temporary avoidance of the area by manatees and secondly and more significantly by enabling faster boat traffic through the Creek and thereby increasing the risk of boat strikes there. The clearance work itself can be assessed as likely to have a temporary low impact on the manatees whilst the indirect impacts of increased speed and frequency of boat traffic are likely to have a medium impact on manatees using this currently quiet backwater access route to Northern Lagoon.

A critical feeding ground for the manatees frequenting the Belize River mouth area are the seagrass beds just off the coast from Ladyville (Galves, J. pers. com.). Injured manatees and stranded calves are not infrequently observed in the Vista Del Mar canals, resting up in sheltered waters. The proposed opening of the link canal to drain the area north of the Highway into the Vista Del Mar Canal is unlikely to have a significant negative impact on the manatees, though the concept of extending the canal to divert a significant volume of water from the Belize River would have very profound negative impacts on the seagrass beds on which the manatees depend. These negative impacts could be somewhat reduced by the installation and operation of gates across the canal, though long-term significant impacts from dredging at the outflow would remain.

Target of Impact	Source of Impact	Potential Scale of Impact	Impact Ranking
Manatees	Re-opening of Black Creek, Mexico Creek and Mussel Creek	Low to Medium	Medium
	Opening and operation of a canal linking the Belize River and the Vista Del Mar (or other) canal	Very High	Very High

6.10.3.2 Endemic Species to savannahs

Four plant species were identified in the Baseline Assessment as endemic to savannahs, and occurring within the Highway buffer area. With close adherence to the best practices laid out in the Mitigation Plan, it is not envisioned that the upgrading of the Highway will have any significant direct impacts on them.

Potential indirect impacts include the potential for increased habitat loss as a result of expanding development on lands adjacent to the Highway. However, it is noted that this expansion has been occurring since the late 1980's, and it is not thought that the upgrading of the Highway will directly significantly impact the rate of this ongoing development in this area. The incremental increase in impacts from the upgrading is therefore assessed as being very low.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Endemic plant species	Upgrading of the Highway	Zero / Very Low	Very Low

6.10.3.3 Species of Cultural / Economic Significance

Several plant and animal species of cultural and/or economic significance were identified as occurring within the Highway buffer area in the Baseline Assessment. Pressures on these species stem primarily from unsustainable levels of extraction and from anthropogenic fires. As the current condition of the Highway does not negatively impact accessibility for natural resource extraction, it is not envisioned that the upgrading of the Highway will have any direct impacts on these species.

As with the endemic plants, possible indirect impacts include the potential for increased habitat loss as a result of expanding development on lands adjacent to the Highway. However, it is noted that this expansion has been occurring since the late 1980's, and it is not thought that the upgrading of the Highway will directly significantly impact the rate of the ongoing development in this area. The incremental increase in impacts from the upgrading is therefore assessed as being very low.

With the scale and the manual work involved in the re-clearing of the Black Creek, Mexico Creek and Mussel Creek waterways, these works will have a low impact on these species of socio-economic significance. With good adherence to the mitigation measures developed in the Mitigation Plan, the impacts from this re-clearance of these biodiverse-rich waterways will be low.

The overall negative impacts of the Highway upgrading and of the waterway clearance, on species of socio-economic significance are therefore assessed as being low.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Species of Cultural / Economic Significance	Upgrading of the Highway	Low	Low

6.10.3.4 Wildlife Movements / Crossings, Road Mortality and Road Avoidance.

The deciduous forests, savannahs, wetlands, and water bodies of the PGH project area support a rich diversity of wildlife outside of protected areas. The impact of a highway structure through this landscape is not only that of reducing interconnectivity of wetlands, but is also a barrier and hazard to wildlife movement.

The Philip Goldson Highway, historically one of the best paved roads in Belize and the primary link between Belize City and the northern districts, is a high-speed road. Legally limited to 55 mph, most traffic traverses the non-urban sections of the Highway at significantly higher speeds, inevitably impacting wildlife as it attempts to cross the Highway. Some species, such as the furrowed wood turtle, were regularly seen crossing the Highway in the late 1980s and early 1990s, often failing and being run over in the process (Walker, P. pers. obs). This species and other similar slow moving turtles are now very rarely seen on the road – almost certainly a reflection of historical road mortality having caused a significant local population decline, rather than the turtle population exhibiting road avoidance. Other vertebrates observed crossing the Highway include jaguar, puma, grison, white-tailed deer, coati, tamandua, raccoon and fox (Walker, P. pers. obs.), with tapir and howler monkey crossings being reported by stakeholder community members. Wildlife road mortality is not uncommon on the Highway, with tamandua, fox, coati and raccoon being the most commonly observed, but others including a jaguar and kinkajou also being seen (Walker, P. pers. obs).

Species that frequent pine savannah ecosystems largely tolerate relatively open areas so a Highway is less of a barrier to their movements than for many forest species that are reluctant to leave the cover of dense vegetation. As such, savannah wildlife species are much less likely to be funnelled to specific road crossings by adjacent vegetation, ridges, creeks, etc. than are forest species, and can be seen crossing the Philip Goldson Highway seemingly randomly along much of its length at it traverses savannah habitats. Nonetheless, the very wide, well-maintained verges along sections of the Highway north of the buffer area of the planned upgrade create a particularly wide barrier for wildlife crossings, even for savannah-dwelling species – such that strong road avoidance can be expected from a number of species within the area, having potentially significant impacts on their long-term viability.

As the planned upgrade of the Highway will largely retain the current width of the pavement and verges, it is not envisioned that it will have a significant incremental increase in negative impacts of wildlife movements across the Highway. There is however the opportunity to reduce impacts from the current Highway, by the improved design and construction of culverts (particularly in areas of broadleaf vegetation) to better facilitate not only unimpeded water flow, but also wildlife movements – these measures are detailed in the Mitigation Plan.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Wildlife Movements / Crossings and Road Mortality	Upgrading of the Highway	Low / Medium	Medium

6.10.3.5 Wildlife Populations

The cumulative direct and indirect impacts of the existing Philip Goldson Highway on wildlife over the 30+ years since its construction are assessed as substantial. Several wildlife species (such as the furrowed wood turtle) are now far less abundant in the area than in the late 1980's, though it is not certain that the construction and use of the Highway is the primary driver of these declines. Although road mortalities are very evident when they occur, the most significant direct impacts of the Highway on populations are likely to be those associated with the barrier effect it has on them – for some broadleaf forest species the population on one side of the road is likely to be effectively a separate one from that on the other, with very little gene flow between them.

As the upgrading of the Highway is intended to fall within the existing right of way, and largely retain the same pavement and verge widths as at present, and without significant (multiple meter) vertical realignments, the **incremental** negative impacts of the upgrade on wildlife populations are however assessed as being low.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Wildlife Populations	Upgrading of the Highway	Low	Low

6.10.4 Habitat Degradation

6.10.4.1 Fire

Belize's coastal savannahs are subject to severe impacts from increasingly frequent anthropogenic fires, with those within the Highway upgrade buffer area being no exception. Fires spread through most areas each year, sometimes more than once in a single dry season (Figure 6.33). Whilst fires on a 5-7 year cycle can promote pine growth (by killing many broadleaf species that compete for space) and are considered necessary for maintenance of the pine savannah, more frequent fires do not allow time for pine sapling growth, so even these are destroyed. The net result of such frequent anthropogenic fire is a significant reduction in species diversity, a drastic decrease in tree density, a lowering of vegetation canopy, an increase in density of fire-tolerant species, and a significant decrease in fauna – including species such as the endangered yellow-headed parrot, reliant on the older growth pine trees for nesting sites.

Hunters have long been blamed for these illegal and devastating fires, setting them to attract deer to the phosphate-rich ashes in the days after the fire and then to the new grass and herbaceous shoots that sprout soon afterwards. More recently, however, it is thought that some fires may be started accidentally by the careless disposal of cigarette butts, or even the sunlight magnification effect of discarded glass jars, etc. There is also concern that some fires may deliberate acts of arson – by individuals wanting to watch as the fires rage across the landscape.

Figure 6.33: Bush fire in front of the Sandhill Police Station (J.R. Rancharan May 28, 2017).

Hunters are known to cover significant distances, so the construction of the Philip Goldson Highway probably only had a minimal impact on their accessibility to savannahs. The increased risk of fire from the other deliberate and accidental sources is therefore considered to be a greater issue. The overall **incremental** impact of the upgrading of the Highway on fire risk is however assessed as being minimal.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Fire risk	Upgrading of the Highway	Very Low	Low

6.10.4.2 Edge Effect

Edge effects of highways include shifts in vegetation species composition and structure, shifts (to and from) verge areas by wildlife, and changes in behaviour (primarily avoidance) of wildlife.

As the upgrading of the Highway is intended to fall within the existing right of way, and largely retain the same pavement and verge widths as at present, the **incremental** negative impacts of the upgrade on edge effect are, however, assessed as being very low.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Edge Effect	Upgrading of the Highway	Very Low	Low

6.10.5 Pollution

6.10.5.1 Noise Pollution

Noise falls under the Pollution Regulations of 1996, which determine the loudness and duration of exposure permissible for various sectors of society. These regulations are geared towards people rather than wildlife, and it is safe to presume that most species of wildlife are far more sensitive to noise pollution than are humans – who by their societal structure and activities are exposed to significant noise pollution on a daily basis. Construction activities, particularly those involving heavy machinery, are by their very nature, loud – from the ongoing rumble of large diesel engines, to the explosive bangs of dump-truck tailgates closing after the discharge of materials. Of wildlife, all but the most habituated species and individuals will display behavioural shifts – most obviously avoidance / displacement – in response to such noise pollution. These impacts are however mostly short-term, with reversion to pre-construction behaviours and presence in most species soon after completion of the construction.

Operational noise associated with the upgraded Highway is unlikely to have any observable incremental increase in impact on wildlife than does the Highway in its current condition, and is therefore assessed as being very low in impact on biodiversity.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Noise Pollution re. wildlife	Upgrading of the Highway	Very Low	Very Low

Noise pollution associated with the proposed re-clearing of the Black Creek, Mexico Creek and Mussel Creek waterways will, however, occur in areas not previously exposed to such disturbance – but with the clearance being limited to manual clearing, the impacts are however mostly short-term, with reversion to pre-clearing behaviours and presence in most species soon after completion of the work.

Target of Impact	Source of Impact	Potential Scale of Impact	Impact Ranking
Noise Pollution re. wildlife	Re-clearance of Black Creek, Mexico Creek and Mussel Creek	Low	Low

6.10.5.2 Soil and Water Pollution

The construction works of the Highway upgrade pose the risk of soil and water pollution from numerous sources including:

- Litter into surrounding areas especially plastic and foam containers
- Sediment run-off from the movement, spreading and rolling of fill material
- Petroleum hydrocarbon run-off during the re-paving
- Oil and grease and fuel spillage from construction vehicle operation and maintenance
- Oil, grease and fuel spillage from vehicular accidents
- Air-borne exhaust fumes and soot particles being deposited on plants, soils and water bodies
- Residue run-off from accidental / deliberate fires

The scale of impacts from these potential sources of pollution range from mild to severe, and are assessed as being a substantially lower risk in the proposed manual re-clearance of the creek waterways. Mitigation measures are detailed in the Mitigation Plan.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Soil and Water Pollution	Upgrading of the Highway and Re-clearance of Creek waterways	Very Low to Severe	High

6.10.5.3 Dust and Air Pollution

Dust from transport, spreading and rolling of fill material for the upgrade can pose a significant health risk to people, but can also have significant impacts on nearby biodiversity. Dust deposition on plant foliage can act as a significant barrier to sunlight available to plants for photosynthesis, impacting metabolic processes and plant health. Dust inhalation by wildlife can pose the same respiratory risks as to people, though in reality species avoidance responses will mean that few individuals are exposed to such high levels as are some people.

Vehicle emissions, particularly from the heavy diesel machinery used in road construction work, often include carbon dioxide, carbon monoxide, nitrogen oxides, sulphur dioxide, and a range of hydrocarbons that can be highly damaging to both people and wildlife. Particulate matter, especially soot particles from diesel engines, is known to cause numerous respiratory issues in terrestrial vertebrates and people alike.

Post-construction operation of the Highway is not assessed as posing any significant **incremental** increase in risk of air pollution impacts. Mitigation measures to minimize these risks are detailed in the Mitigation Plan.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Air Pollution	Upgrading of the Highway and Re-clearance of Creek waterways	Low to High	Low / Medium

6.10.6 Environmental Services

6.10.6.1 Water Sink / Flood Mitigation

The critical role played by the wetlands across the landscape through which the Highway runs is detailed in the Baseline Assessment. This functionality has already been negatively impacted by the original construction of the Highway. The issues of not incorporating adequate culverts and bridges to allow unimpeded of floodwaters, with the Highway effectively having acted as a dam along much of its path, have been identified, with mitigation actions proposed in the mitigation section. Many of these design inadequacies have been subsequently improved by the installation of larger culverts and the construction of the Mexico Creek Bridge, though there is still scope for significant rectification of remaining inadequacies in the re-design and upgrading of the Highway. The upgrading of the Highway is not assessed as posing incremental increased water sink / flood mitigation risk, but does provide the opportunity to rectify past and ongoing impacts.

Great caution should be exercised when considering "improving" flow of Black Creek, Mexico Creek, and Mussel Creek. All of these streams are draining protected areas or areas that should be protected. They are also pathways through which several aquatic; mostly marine (tarpon, jacks, snappers, shrimps, crabs, sometimes manatees) species travel to and from those inland-protected areas (Northern Lagoon, Southern Lagoon, Jones Lagoon, Cox Lagoon). These are largely backwater streams that drain wetland areas and that differ ecologically from white-water streams. Wood is a critical element of their ecology, providing habitats, stabilizing beds, serving as a slow-release nutrient source, dissipating flood energies, and ultimately feeding marine detritivores.

With that being said, it is recognized that recent hurricane damage has resulted in larger amounts of wood occurring within these streams, particularly within certain reaches. The lower end of Mexico Creek just before it bends to enter the Belize River is an example. Careful clearing of these areas by hand-held tools, removing those recently introduced tree roots, trunks, and branches blocking flow while leaving adequate amounts of wood in place to provide ecological services can improve flow while having minimal impact.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Water Sink / Flood Mitigation	Upgrading of the Highway and Re-clearance of creek waterways	Negative : Low Positive: High	Low

6.10.6.2 Soil deposition / retention

As the upgraded Highway will remain within the current right of way and overlay the current pavement and verges, habitat disturbance (e.g. for machinery and material compounds) strictly limited to existing cleared / impacted areas, and with the potential for rectifying past negative impacts on water flow, the construction is not assessed as posing a threat of measurable negative impact on soil deposition or retention.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Soil deposition / retention	Upgrading of the Highway	Very Low	Very Low

6.10.6.3 Carbon Sequestration

As the upgraded Highway will remain within the current right of way and overlay the current pavement and verges, with habitat disturbance (e.g. for machinery and material compounds) strictly limited to existing cleared / impacted areas, it is not assessed as posing a threat of negative impact on carbon sequestration by surrounding ecosystems.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Carbon sequestration	Upgrading of the Highway	Extremely Low	Extremely Low

6.10.6.4 Game Species

The upgrading of the Highway should not have **incremental** direct negative impacts on game species, over and above those of the existing Highway. The risk of indirect impacts – e.g. through potentially increased accessibility for hunters – is assessed as low, as the upgrading is unlikely to impact hunters who are generally willing to traverse far worse roads than the Highway in its current condition.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Game Species	Upgrading of the Highway	Extremely Low	Extremely Low

6.10.6.5 Genetic Bank

Whilst the upgrading of the Highway should not have **incremental** direct negative impacts on the gene bank services of adjacent ecosystems within its buffer area, the potential indirect impacts of land-use change resulting from the increased investment attractiveness associated with improved road surface could negatively impact this environmental service. As most adjacent lands are now in private ownership, opportunities to restrict land-use change are limited.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Genetic Bank	Upgrading of the Highway	Medium	Medium

6.10.7 Indirect Impacts

The potential **incremental** negative direct impacts from the upgrading of the Highway are mostly assessed as being Low and relatively easily mitigated. The indirect impacts however, including the risk of increased land use change and illegal solid waste dumping, have the potential to have long-lasting impacts on the environment and be harder to mitigate.

On the other hand, the **direct** impacts of the planned re-clearance of the Black Creek, Mexico Creek and Mussel Creek waterways have the potential to have very significant impacts on ecosystems and biodiversity, with the likelihood of outweighing the **indirect** impacts if done with heavy machinery.

6.10.7.1 Land Use Change

a. Urban and Industrial Spread

Urban expansion and industrial spread has been observed to radiate along most highways in Belize in recent decades, reflecting numerous factors including improved access, increasing land values, taxation thresholds that are low, movement out of Belize City, increasing private ownership, etc. This trend is likely to continue irrespective of whether the highway is upgraded or not, though one would expect the rate of change to increase. Given the extensive private ownership of lands throughout most of the buffer zone, there is only limited scope for its reduction / mitigation. Where lands include wetlands or are adjacent to waterways, there is some degree of regulation available through the Department of the Environment and Forestry legislation and policies.

b. Agriculture

Limited agricultural values of savannah soils is the biggest limiting factor to agricultural expansion in this area – though this is changing further north adjacent to the Highway where significant investments have been made converting marginal lands into cattle pasture. Seasonal inundation of some of the broadleaf ecosystems also renders them unattractive for agricultural development, though even this could change with sufficient investment, as suitable lands become increasingly in short supply.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Land Use Change	Upgrading of the Highway	Low	Low

6.10.8 Cumulative Impacts

6.10.8.1 Upgrading of the Philip Goldson Highway

The varied impacts on biodiversity, ecosystems and ecosystem services that will be caused by the upgrading of this section of the Philip Goldson Highway, are mostly assessed as being Extremely Low to Low, if there is good adherence to best practices and the mitigation activities detailed in the Mitigation Plan. Taken together their overall cumulative impact is assessed as medium: manageable and justifiable within the context of national development.

6.10.8.2 Clearing of the Main Drain

Given that the main drain already exist within the expansion area of Ladyville and that the area is already encircled by the Highway and urban roads, coupled with the fact that it will be re-opened into a pre-existing canal system, the cumulative impacts of the clearing are assessed as being Low. Taken with the cumulative impacts of the Highway upgrade, the overall impacts will be of a low scale.

6.10.8.3 Restoration of cross section of Creek waterways

The individual impacts on biodiversity, ecosystems and ecosystem services caused by the restoration of the cross section of the Black Creek, Mexico Creek and Mussel Creek waterways, with good adherence to the mitigation activities detailed in the Mitigation Plan, are mostly assessed as being low to high, with the potential impacts on a globally important population of the critically endangered Central American river turtle (hicatee) being assessed as Very High without implementation of adequate mitigating actions. Taken together, the cumulative impacts from this planned work are assessed as likely to have a low negative impact on biodiversity and ecosystems. Although the removal of tree debris and snags from the waterway will be limited to manual removal, which is considered low impact, the planned clearing could have severe impacts on the hicatee and its habitat, primarily by exposing them to increased accessibility from hunters.

It is important also to consider impacts as they accumulate over time. Whilst some will diminish as vegetation regrows and wildlife adjust behaviour, indirect impacts such as land-use change will not. Whilst the filling of an individual house lot within a flood basin may not have a profound impact on flood sink / control ecosystem services provided by the wetland ecosystems, each such development adds to the previous impacts in a trend that could in the future have severe and costly impacts on urban flooding in Belize City and Ladyville. Improved and enforced implementation of holistic land-use planning is needed if wetland drainages are not to be obstructed in their critical flood control functionality. The excavation of canals and large drainage ditches to rectify poor planning is a costly and inefficient (and usually ineffective) approach to trying to provide an alternative.

6.10.9 Summary of Ecological Impacts

The summary of the Ecological Impacts of the PGH on the study area's ecosystem is presented in Tables 6.13 and 6.14.

Table 6.13: Summary of Ecological Impact.

Target of Impact	Source of Impact	Potential Scale of Incremental Impact	Impact Ranking
Ecosystem Loss	Increased Road footprint	Minimal	Very Low
Ecosystem Loss	Clearing of Main Drain	Low	Low
Ecosystem Connectivity (Highway)	Road Footprint	Negligible	Very Low
Ecosystem Connectivity (Main Drain)	Clearing of Main Drain	Low	Low
Increased Edge Effect	Road Footprint	Negligible	Very Low
Hicatee	Re-opening of Black Creek, Mexico Creek and Mussel Creek (Manual)	Low to High	Low to High
Tapirs and tapir habitat	Re-opening of Black Creek, Mexico Creek and Mussel Creek (Manual)	Low to medium	Low to Medium
Howler monkeys and their habitat	Re-opening of Black Creek, Mexico Creek and Mussel Creek (Manual)	Low to medium	Low to Medium
Yellow-headed parrot	Upgrading of Highway	Very Low / Low	Very Low
Jabiru Stork – nesting site	Upgrading of Highway	Very Low / Low	Low
Endemic plant species	Upgrading of the Highway	Zero / Very Low	Very Low
Species of Cultural / Economic Significance	Upgrading of the Highway	Low	Low
Wildlife Movements / Crossings and Road Mortality	Upgrading of the Highway	Low / Medium	Medium
Wildlife Populations	Upgrading of the Highway	Low	Low
Fire risk	Upgrading of the Highway	Very Low	Low
Noise Pollution re. wildlife	Upgrading of the Highway	Very Low	Very Low

Noise Pollution re. wildlife	Re-clearance of Black Creek, Mexico Creek and Mussel Creek	Medium	Low to Medium
Soil and Water Pollution	Upgrading of the Highway and Re-clearance of Creek waterways	Low to High	Low to High
Air Pollution	Upgrading of the Highway and Re-clearance of Creek waterways	Low to High	Low / Medium
Water Sink / Flood Mitigation	Upgrading of the Highway and Re-clearance of creek waterways	Negative : Low Positive: High	Low
Soil deposition / retention	Upgrading of the Highway	Very Low	Very Low
Carbon sequestration	Upgrading of the Highway	Extremely Low	Extremely Low
Game Species	Upgrading of the Highway	Extremely Low	Extremely Low
Genetic Bank	Upgrading of the Highway	Medium	Medium
Land Use Change	Upgrading of the Highway	Low	Low
Solid Waste Disposal	Upgrading of the Highway. Re-clearance of Creek waterways	Medium	Medium

Table 6.14: Impact Assessment Matrix on Impacts to Ecosystem.

IMPACT	DETAILS	IMPORTANCE	MAGNITUDE	EXTENT	PERMANENCE	SPHERE OF INFLUENCE	MITIGABILITY	REVERSIBILITY	PROBABILITY OCCURRENCE
CONSTRUCTION PHASE IMPACTS									
Excavation of fill material	Removing fill material from distant locations and transporting it to the site contributing to land degradation and habitat loss off site	H	H	M	P	W	M	M	H
Deposition/compaction of fill material	Dumping and working fill material at project site to build road bed, reducing porous surface area	M	Lo	M	P	W	H	Lo	H
Removal and disposal of old surface material	Scraping up and removing old asphalt and concrete from highway surface, improper disposal of this material can result in habitat loss, land degradation, and water quality issues from erosion of materials into waterways and coastal zone.	M	Lo	M	T	W	H	H	H
Erosion and sediment discharge from new roadbed	Fresh sediment created by storm water discharge over newly created areas, depositing materials into water bodies	H	Lo	La	P	W R	H	H	H
Unnecessary damage to wetlands by heavy equipment	Habitat destruction caused by turning heavy equipment around and by unnecessary road or access building, tread damage, pushing further than necessary into bush areas and riparian zones, cleaning equipment in stream	H	M	M	T	C W	H	M	H
Unnecessary compaction of soil adjacent to construction site	Movement of heavy equipment and vehicles over soil surface around project site, compacting soil and reducing infiltration rates	M	S	S	T	C W	H	H	H

IMPACT	DETAILS	IMPORTANCE	MAGNITUDE	EXTENT	PERMANENCE	SPHERE OF INFLUENCE	MITIGABILITY	REVERSIBILITY	PROBABILITY OF OCCURRENCE
Re-diverting stream flow during bridge construction	Changing channel direction of active streams during early wet season, potential damage to riparian forests increasing sedimentation	H	M	La	T	C W	M	M	H
Construction of drainage ditches along highway	Increased concentrated discharge of storm water, increased erosion of ditch bed, increased sedimentation of river beds	H	M	La	T P	W R	H	M	H
Application of fresh pavement to road surface	Air pollution from volatile components, storm water erosion of soluble components carried to streams and wetlands that may be toxic to aquatic life	M	M	M	T	C W	L o	H	H
Leakage of oil and other fluids from heavy equipment	Soluble components carried to streams by storm water discharge may be toxic to aquatic life	M H	Lo M	S M	T	C W	H	M H	H
Noise and vibrations	Disturbance of wildlife, disruption of wildlife movement	M	Lo	S	T	C	L o	H	H
Dust and exhaust	Air pollution, settling of dust and exhaust into wetlands and waterways by rains, affecting turbidity, acidity and other water quality parameters	M	Lo	S	T	C W	L o	H	H
Piles of large waste materials	Concrete, steel, scrap materials, old asphalt cover potential habitat areas, adding leachate from rain water, loss of aesthetics	Lo	Lo	S	T P	C	H	H	H
Garbage from road workers	Solid waste entering waterways and wetlands, food attracting wildlife to heavy traffic areas, burning releases toxic materials into atmosphere, loss of aesthetics	Lo	Lo	S M	T	C W	H	H	H

POST CONSTRUCTION IMPACTS									
IMPACT	**DETAILS**	**IMPORTANCE**	**MAGNITUDE**	**EXTENT**	**PERMANENCE**	**SPHERE OF INFLUENCE**	**MITIGABILITY**	**REVERSIBILITY**	**PROBABILITY OF OCCURRENCE**
Clearing of Main Drain (Vista Del mar)	Destruction of habitat from clearing and disposal of cleared material, increased sediment load into receiving water body	H	Lo	La	P	C W	Lo	Lo	H
Maintenance of Main Drain (Vista Del Mar)	disposal of cleared material destroys habitat, increased sedimentation into receiving water body	H	Lo	La	P	C W	Lo	Lo	H
Discard of solid waste from passing vehicles	Solid waste in streams and wetlands, creates mosquito breeding sites, lures wildlife to roadside for food scraps, reduces aesthetics	M H	M	M	P	C W	H	H	H
Disruption of wildlife movement	Highway reduces movement of many wildlife species, restricts genetic flow, creates conditions for isolation of small populations	H	H	La	P	W R	Lo	Lo	H
New development along refurbished highway	Loss of habitat, reduction of wetland areas, reduced flood absorption by land filling, increased pollution from solid and liquid wastes, increased noise, reduced wildlife movement	H	La	M La	P	C W	Lo	Lo	H
Sewage discharge from roadside development	Increased nitrification of water bodies, increased algal and aquatic plant growth, increased anaerobic condition	H	ML a	M La	T P	C W	H	M H	H
Solid waste from roadside development	Solid waste in water bodies and wetlands, increased mosquito breeding, reduced aesthetics, burning of solid waste introduces toxic materials into atmosphere	M	M	M	P	C W	H	H	H
Road/drive construction	Increased habitat loss, increased division of wetlands and water	M H	MH	M	P	C	Lo	Lo	H

	bodies, increased sedimentation								
Continual erosion by storm water discharge	Slope surfaces left unvegetated will continue to contribute sediment loads to water bodies	M H	M	M	T P	C W	H	H	H
Disruption of water movement in wetlands by roadbeds	Causes some wetland areas to dry up and others to flood, reduces wetland and water body services, production, and flood control	H	M	M	T P	C W	M	Lo	H
Habitat destruction	Loss of local biological diversity, degradation of the land, reduced ecological complexity, reduced aesthetics	H	M	M	T P	C W R	M H	M	H

H, M, Lo — High, Medium, Low for *Importance, Magnitude, Mitigability, Reversibility*, and *Probability of Occurrence*.
S, M, La — Small, Medium, Large for *Extent* [of area] affected
T, P — Temporary, Permanent for *Permanence*.
C, W, N, R — Community, Watershed, National, Regional for *Sphere of Influence*.

6.11 Environmental Impacts and Mitigation Measures

6.11.1 Summary of Potential Impacts

While the proposed rehabilitation project is projected to have significant positive social and economic benefits it has the potential to affect the surrounding air and water quality; exacerbate soil erosion and soil stability, and the hydrology and drainage of the area as well. The impacts to the wetlands ecosystems and wildlife within the project area is reduced by the fact that the project entails the rehabilitation of an existing highway with the potential to improve connectivity through improved culverts and drainage allowing for improved flow of water across the highway. In addition, to these environmental issues, the activities of the proposed road rehabilitation activities will temporarily, negatively impact the lives of residents of communities along the ROW and road users. In the areas requiring horizontal alignments outside the road right of way and junctions for proposed runabouts, there will be the need for the acquisition of small strips of private properties. The potential social impacts are discussed in the section pertaining to social impacts. It is expected that at the end of the road rehabilitation project there will be significant net positive social and economic benefits and an improved quality of life for residents of the study area and the remaining Belizean populace. The assessment provides abatement measures that are tailored to reduce these potential adverse impacts to the point where the impacts are insignificant or within acceptable limits, either through effective design and best practices or through sound Environmental Management System (EMS) of the road rehabilitation activities.

An environmental impact is defined as *"any change to an existing condition of the environment*". A social impact likewise refers to "*any change to an existing condition of the social fabric of the communities"* along the ROW. The nature of the impacts may be categorized in terms of:

- Direction -positive or negative
- Duration -long or short term
- Location -direct or indirect
- Magnitude -large or small
- Extent -wide or local
- Significance -large or small

Tables 6.15, 6.16 and 6.17 provides three different types of impact matrix summarizing the potential environmental impacts associated with the activities of the road rehabilitation activities looking at the general road activities and the critical areas of concerns and major accompanying activities. The first matrix (Table 6.15) assesses the direction, duration, location, magnitude, extent, and significance of the projected impacts.

Table 6.16 classifies the identified environmental impacts based on importance, magnitude, extent, permanence (temporary or permanent), sphere of influence (local, regional), mitigability, reversibility, and probability of occurrence. While Tables 6.17 looks at the road activities and provides a quantitative assessment of the impacts on the various environmental elements of concern relative to each other.

As can be seen from the matrices most of the impacts are predicted as either minimal to medium, are very localized and of short duration. The activities with the highest impacts are those associated with the concept of the link canal, construction of new bridge followed closely by road alignment and earthmoving activities requiring that close attention be placed on these main activities especially when occurring within the identified critical areas identified. It is recommended that the proposed link canal be looked at more closely prior to implementation.

Table 6.15: Impact Matrix Assessing the Characteristic of Impacts.

	ACTIVITY/IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
		(+)	(-)	Long	Short	Dir	Ind	Maj	Min	Wide	Local	Large	Small
General Road Construction Activities	Road construction impacts to ecology	x		x		x			x		x	x	
	Road construction Impacts to wildlife	x		x			x		x		x		x
	Road Construction Activity on Archaeology		x	x			x		x		x		x
	Camp Site Construction		x		x		x		x		x		x
	Extraction of Material		x		x	x			x		x		x
	Transportation of Materials		x		x	x			x		x		x
	Road Paving Activities	x		x		x		x		x		x	
	Movement of heavy equipment		x		x	x			x		x		x
	Road Construction		x		x	x		x		x		x	
	Horizontal Road Alignments			x		x		x			x	x	
	Raising approaches to new-Mexico Creek Bridge		x	x		x		x		x		x	
	Raising Highway from Pigeon Street to Old Airport Road		x	x		x		x			x	x	
	Raising of Highway by .5 meters to address climate change		x	x		x		x			x		x
	Construction of new-Mexico Creek Bridge		x		x	x		x			x	x	
	Installation of new Culverts			x									
	Replacement of Culverts from Sandhill to Gardenia	x		x		x		x			x	x	
	Replacement of Culverts from Burrell Boom Junction to Sandhill Junction	x		x		x		x			x		x
	Replacement of Culverts from Ladyville to Burrell Boom Junction	x		x		x		x			x		x
	Construction of Roundabout at International Airport	x		x		x		x		x	x	x	

	Junction												
	Construction of Roundabout at Lords Bank Junction	x		x		x		x			x		
	Construction of Roundabout at Burrell Boom Junction	x		x		x		x		x	x	x	
	Rehabilitation of Vista Del Mar main drain	x		x		x		x			x		
	Construction of lateral Drains in the Ladyville to Lords Bank section	x		x		x		x			x		
	Construction of Poinsettia and Marage Street proposed drainage system	x		x		x		x			x		
	Construction of Lord Bank Road lateral drain and sedimentation Pond	x		x		x		x			x		
	Construction of Mile 13 drainage system to link up to Calva Pond Creek south of the old Nova shrimp farm.	x		x		x		x			x		
	Proposed concept for a Link Canals in Cloverleaf Area to the Sea		x	x		x		x			x		
	Proposed concept for a 5-meter-wide Canal in the Vista Del Mar from the river to the Sea.		x	x		x		x			xx		
Dir. Direct Ind. Indirect Maj. Major Min. Minor													

Table 6.16: Impacts classified based on importance, magnitude, extent, permanence (temporary or permanent), sphere of influence (local, regional), mitigability, reversibility, and probability of occurrence.

IMPACT	DETAILS	IMPORTANCE	MAGNITUDE	EXTENT	PERMANENCE	SPHERE OF INFLUENCE	MITIGABILITY	REVERSIBILITY	PROB. OF OCCURR.
CONSTRUCTION PHASE IMPACTS									
Excavation of fill material	Removing fill material from distant locations and transporting it to the site contributing to land degradation and habitat loss off site	H	H	M	P	W	M	M	H
Deposition/compaction of fill material	Dumping and working fill material at project site to build road bed, reducing porous surface area	M	Lo	M	P	W	H	Lo	H
Removal and disposal of old surface material	Scraping up and removing old asphalt and concrete from highway surface, improper disposal of this material can result in habitat loss, land degradation, and water quality issues from erosion of materials into waterways and coastal zone.	M	Lo	M	T	W	H	H	H
Erosion and sediment discharge from new roadbed	Fresh sediment created by storm water discharge over newly created areas, depositing materials into water bodies	H	Lo	La	P	W R	H	H	H
Unnecessary damage to wetlands by heavy equipment	Habitat destruction caused by turning heavy equipment around and by unnecessary road or access building, tread damage, pushing further than necessary into bush areas and riparian zones, cleaning equipment in stream	H	M	M	T	C W	H	M	H
Unnecessary compaction of soil adjacent to construction site	Movement of heavy equipment and vehicles over soil surface around project site, compacting soil and reducing infiltration rates	M	S	S	T	C W	H	H	H
Re-diverting stream flow during bridge construction	Changing channel direction of active streams during early wet season, potential damage to riparian forests increasing sedimentation	H	M	La	T	C W	M	M	H
Construction of drainage ditches along highway	Increased concentrated discharge of storm water, increased erosion of ditch bed, increased sedimentation of river beds	H	M H	M La	T P	W R	M H	M	H
Application of fresh pavement to road surface	Air pollution from volatile components, storm water erosion of soluble components carried to streams and wetlands that may be toxic to aquatic life	M	M	M	T	C W	Lo	H	H
Leakage of oil and other fluids from heavy equipment	Soluble components carried to streams by storm water discharge may be toxic to aquatic life	M H	Lo M	S M	T	C W	H	M H	H
Noise and vibrations	Disturbance of wildlife, disruption of wildlife movement	M	Lo	S	T	C	Lo	H	H

Dust and exhaust	Air pollution, settling of dust and exhaust into wetlands and waterways by rains, affecting turbidity, acidity and other water quality parameters	M	Lo	S	T	C W	Lo	H	H
Piles of large waste materials	Concrete, steel, scrap materials, old asphalt cover potential habitat areas, adding leachate from rain water, loss of aesthetics	Lo	Lo	S	T P	C	H	H	H
Garbage from road workers	Solid waste entering waterways and wetlands, food attracting wildlife to heavy traffic areas, burning releases toxic materials into atmosphere, loss of aesthetics	Lo	Lo	S M	T	CW	H	H	H
Clearing of Main Drain (Vista Del mar)	Destruction of habitat from clearing and disposal of cleared material, increased sediment load into receiving water body	H	Lo	La	P	C W	Lo	Lo	H
POST CONSTRUCTION IMPACTS									
Maintenance of Main Drain (Vista Del Mar)	disposal of cleared material destroys habitat, increased sedimentation into receiving water body	H	Lo	La	P	C W	Lo	Lo	H
Discard of solid waste from passing vehicles	Solid waste in streams and wetlands, creates mosquito breeding sites, lures wildlife to roadside for food scraps, reduces aesthetics	M H	M	M	P	CW	H	H	H
Disruption of wildlife movement	Highway reduces movement of many wildlife species, restricts genetic flow, creates conditions for isolation of small populations	H	H	La	P	WR	Lo	Lo	H
New development along refurbished highway	Loss of habitat, reduction of wetland areas, reduced flood absorption by land filling, increased pollution from solid and liquid wastes, increased noise, reduced wildlife movement	H	La	M La	P	CW	Lo	Lo	H
Sewage discharge from roadside development	Increased nitrification of water bodies, increased algal and aquatic plant growth, increased anaerobic condition	H	MLa	MLa	T P	C W	H	M H	H
Solid waste from roadside development	Solid waste in water bodies and wetlands, increased mosquito breeding, reduced aesthetics, burning of solid waste introduces toxic materials into atmosphere	M	M	M	P	CW	H	H	H
Road/drive construction	Increased habitat loss, increased division of wetlands and water bodies, increased sedimentation	MH	MH	M	P	C	Lo	Lo	H
Continual erosion by storm water discharge	Slope surfaces left unvegetated will continue to contribute sediment loads to water bodies	MH	M	M	T P	CW	H	H	H
Disruption of water movement in wetlands by roadbeds	Causes some wetland areas to dry up and others to flood, reduces wetland and water body services, production, and flood control	H	M	M	T P	CW	M	Lo	H
Habitat destruction	Loss of local biological diversity, degradation of the land, reduced ecological complexity, reduced aesthetics	H	M	M	T P	C W R	M H	M	H

H, M, La High, Medium, Low for *Importance, Magnitude, Mitigability, Reversibility*, and *Probability of Occurrence*.
S, M, Lo Small, Medium, Large for *Extent* [of area] affected
T, P Temporary, Permanent for *Permanence*.
C, W, N, R Community, Watershed, National, Regional for *Sphere of Influence*.

Table 6.17: Matrix Quantifying Impacts of General Road Rehabilitation Activities.

Environmental Effects			Impacts on land					Aquatic Environment			Air quality and Noise				Water Quality			Hydrology of Area							Total
Developmental Activities	Habitat loss	wetlands connect.	wildlife	Protected Areas	Land Use	Erosion	Land pollution	drainage	Fish & species loss	Fish Movement	Aquatic Plants	Emissions	Dust	Noise Level	Oil/ hydrocarbons	Siltation-TSS	Bact. contamination	Dissolved Oxygen	Siltation	Flow regime	Drainage	Drinking water	Bank Erosion	Riparian vegetation	
General Earth moving activities	-1	-1	-2	-2	0	-2	-1	2	-1	0	-2	-2	-2	-2	-1	-2	-1	-1	-2	2	3	-1	-1	-1	-21
Camp site	0	0	-1	-1	-1	-1	-2	0	0	0	0	-1	-1	-1	-2	-1	-2	-1	-2	0	0	0	0	0	-18
Extraction of Material	-2	-1	-1	-1	0	-2	0	-1	0	-1	0	-1	-1	-1	-1	-2	-1	-1	-2	0	0	-1	0	0	-20
Drainage construction	-1	-1	-1	-1	-1	-2	0	3	1	1	0	-1	-2	-2	-1	-2	-1	-1	-3	-1	0	0	-2	-2	-20
Road paving	0	0	0	0	0	2	0	-2	0	0	0	-2	-2	-2	-2	-2	-1	-1	-3	-1	-1	-2	-3	-2	-24
Movement of heavy equipment	0	0	0	0	0	-1	0	0	0	0	0	-2	-2	-2	-2	-2	-1	-1	-3	-1	2	1	-2	-2	-18
Road alignments (combined)	-2	-1	-2	-2	-1	-2	0	2	-1	-1	-1	-1	-2	-2	-2	-2	-1	-1	-2	-3	0	-1	0	0	-28
Raising approaches to a new Mexico Creek Bridge	0	0	0	0	0	-2	-2	-2	-1	0	0	-2	-2	-2	-2	-2	-2	0	-2	-2	-1	0	0	0	-24
Construction of Mexico Creek Bridge	-1	-1	-1	0	-1	-2	-2	-2	-2	-2	-2	-1	-1	-1	-1	-2	-1	-1	-2	-1	-1	-1	-1	-1	-31
Raising Highway from Pigeon Street to Old Airport Road	0	0	0	0	0	-1	-2	2	0	0	0	-2	-2	-2	-2	-2	-1	-1	-2	-2	-1	-2	-2	-1	-23
Raising of Highway by 0.5 meters to address climate change	-1	-1	-1	0	0	-1	-2	2	0	0	0	-2	-2	-2	-2	-2	-1	-1	-2	-2	-1	-2	-2	-1	-25
Installation of new and Replacement of Culverts	2	2	2	0	0	0	-2	2	0	1	1	-2	-2	-2	-2	-2	-1	-1	-2	2	2	-2	0	0	-4
Construction of Roundabout at PGIA Junction	0	1	0	0	-2	-1	-2	2	0	1	0	-2	-2	-2	-2	-2	-1	-1	-2	2	2	-2	0	0	-13

Construction of Roundabout at Poinsettia Street	-1	1	0	0	-2	-1	-2	2	0	1	0	-2	-2	-2	-2	-2	-1	-1	-2	2	2	-2	0	0	-14
Construction of Roundabout at Marage Road Junction	-1	1	0	0	-2	-1	-2	2	0	1	0	-2	-2	-2	-2	-2	-1	-1	-2	2	2	-2	0	0	-14
Construction of Roundabout at Lords Bank Junction	0	1	0	0	-2	-1	-2	2	0	1	0	-2	-2	-2	-2	-2	-1	-1	-2	2	2	-2	0	0	-13
Construction of Roundabout at Burrell Boom Junction	-1	1	-1	0	-2	-1	-2	2	0	1	0	-2	-2	-2	-2	-2	-1	-1	-2	2	2	-2	0	0	-15
Rehabilitation of Vista Del Mar main link drain	-1	2	-2	0	0	-1	-2	2	2	2	0	-1	0	-1	-2	-2	-2	-2	-2	3	3	-2	-2	-2	-10
Construction of lateral Drains in the Ladyville to Lords Bank section	0	2	0	0	0	-1	-2	2	0	1	0	-1	-1	-1	-2	-2	-2	-2	-2	3	3	-2	-2	-2	-11
Construction of Poinsettia and Marage Street proposed drainage system	0	2	0	0	0	-1	-2	2	0	1	0	-1	-1	-1	-2	-2	-2	-2	-2	3	3	-2	-2	-2	-11
Construction of Lord Bank Road lateral drain and sedimentation Pond	-1	2	-1	0	0	-1	-2	2	1	1	-1	-1	0	-1	-2	-2	-2	-2	-2	2	2	-2	-1	-1	-12
Construction of Mile 13 drainage system to link up to Calva Pond Creek south of the old Nova shrimp farm.	-2	2	-2	0	-2	-1	-2	2	1	1	-1	-2	-2	-2	-2	-2	-2	-2	-2	2	2	-2	-1	-1	-20
Proposed concept for a Link Canal in Clover Leaf Area to the Sea	-3	-3	-3	-3	-3	-1	-2	3	-2	2	-2	-2	-2	-2	-2	-2	-2	-2	-2	2	2	-2	-3	-3	- 37
Proposed concept for a 30 meter- wide Canal in the Vista Del Mar from the river to the Sea.	-3	-3	-2	-3	-3	-1	-2	3	-2	2	2	-2	-2	-1	-2	-2	-2	-2	-2	1	2	-2	-3	-3	-38
Clearance of Creeks of fallen trees and snags blockage	-1	2	-2	0	0	-1	-2	2	2	2	0	-1	0	-1	-2	-2	-2	-2	-2	3	3	-2	-2	-2	-10
Impacts: -3 High negative; -2 Medium negative; -1 Low negative 0 none; 1 Low positive; 2 Medium positive; 3 High positive																									

6.12 Social Impacts and Mitigation Measures

The International Principles for Social Impact Assessment (SIA), (IAIA, 2003) recognize that social, economic and biophysical impacts are inherently and inextricably interconnected. Change in any of these domains will lead to changes in the others. Social impact assessment includes the processes of analyzing, monitoring, and managing the intended and unintended social consequences, both positive and negative, of planned interventions and any social change processes invoked by those interventions. The primary purpose of the SIA is to bring about a more sustainable and equitable biophysical and human environment.

Too this end, the SIA is designed to ensure that the Project's potential and perceived impacts on affected individuals/groups of people are understood so that positive impacts can be enhanced by the project design while negative ones mitigated, without compromising the objectives of the proposed road project and its benefits for project affected persons (PAPs). Ideally, this should be achieved without negative impacts.

Findings from the Baseline Survey and ROW Census and analyses of secondary data sources combined with evidence generated from the focus group discussions, key informant interviews and direct field observations form the basis for identification of the potential positive and negative impacts on individuals and groups of people during the different stages of the Project in a transparent manner and, in accordance with national laws and international safeguards.

For completeness and to complement the assessment of social impacts, a social risk analysis has been undertaken with the explicit aim of: identifying the potential risks to the project stakeholders and to the Project; avoiding potential risks by suggesting precaution or risk mitigation measures, taking into account any future actions, project developments and/or project context risk that may impose social stress or conflict; advising the Client of stakeholders' expectations and grievances; and promote consensual decision-making and realistic participation in agreements for problem solving and/or risk mitigation.

6.12.1 Methodology

The methodology used for assessing the significance of environmental impacts for the Project, earlier described in this ESIA Report, Section 1.1, has been adapted to assess social impacts.

This adapted methodology is described below and relies on the use of specified impact indicators and established criteria for the assessment of the significance of social impacts.

6.12.1.1 Impact Indicators and Valued Receptors

For purposes of this Social Impact Assessment, an impact indicator is defined as any human/social/ environmental indicator considered important or valuable and thus meriting consideration in the SIA process. The process of selecting impact indicators considered, among other things, national, regional and local context, legal status, cultural value, and accounted for the perceptions of national and local government, international, national and/or local non-governmental organizations and the Project's directly and indirectly affected persons. Additionally, for purposes of this SIA, valued (social) receptors (VRs) are defined as individuals, socio-cultural groups and community organizations or entities. They may be service users or employees, community residents, a specific neighbourhood, or visitors.

The methodology used to assess impact significance varies from that of environmental VRs described in Section 1.1 in that the 'human environment' comprises social, health, cultural, demographic and economic aspects and it is not directly possible to categorize the 'sensitivity' of social VRs to different impacts simply as 'low', 'medium' or 'high'. This is because the 'sensitivity' of social VRs relates to a complex mix of the vulnerability of different groups and individuals to Project impacts and to public perception of Project impacts. This is important because public perception of potential impacts is a key factor in relation to social risk, i.e. even if there is no clearly apparent scientific basis for a perceived impact, it still may contribute to social risk if people believe a Project activity may have a negative or positive impact. In fact, unlike other types of EIA receptors, such as an animal species, a body of water or the ambient air, recognition that the very mention of the proposed road project may create levels of anxiety/stress which would affect people's actions and responses from that point onward.

6.12.1.2 Methods and Criteria

Social impacts may be caused by the various Project activities and may be direct, indirect, or cumulative in nature. As noted above, because it is not possible to definitively classify the 'sensitivity' of social VRs, unlike environmental VRs, the evaluation of the significance of social impacts has necessarily, some differences to that used in Section 1.1 to classify environmental impacts. In contrast, the evaluation of social impacts used the following three basic criteria for assessing significance:

- Magnitude: The importance of the impact for people's quality of life, health, livelihoods and social relations;
- Spatial Extent: this is also known as the impact area of influence which is the population and/ or geographical area over which the impact is experienced, i.e. the local communities across the ROW and within the defined Study Area; and
- Duration: The length of time or level of permanence over which the impact will be experienced.

Table 6.18 outlines the criteria for measuring magnitude, extent, and duration; individual scores for magnitude, extent, and duration range from 1 – 5, assigned according to an evaluation of the highest criteria that might be expected to result from each impact. Each potential impact is then allocated a significance ranging from 1: very low to 5: very high, based on the arithmetic mean of the assigned scores for magnitude, extent, and duration.

Table 6.18: Criteria for Assessing Social Impacts.

S = [a + b + c]/3 Significance [1 ↔ 5]	(a) Magnitude [1 ↔ 5]	(b) Extent [1 ↔ 5]	© Duration [1 ↔ 5]
Very low **[1]**	***Slight/negligible*** impacts on quality of life, resulting in no measurable effect on lives, livelihoods or health	Immediate vicinity of the project site; one or more but less than 5 persons affected.	Temporary; lasting less than a week.
Low **[2]**	***Minor*** measurable impacts on lives, assets, livelihoods, quality of life and temporary health impacts/minor injury	Localized; less than 15 persons affected.	Short-term, lasting two-three months; health or livelihood impacts that require recovery time of days/less than a week
Moderate **[3]**	***Considerable*** measurable impacts on livelihoods or assets; major health effects/injury. Considerable discontent in the community/labour force.	Multiple locations within the Study Area; more than 20 persons affected. Extensive coverage in local media	Medium-term, lasting six-nine months; health/livelihoods impacts on affected persons/ communities lasting three or more months.
High **[4]**	***Major*** measurable impacts on people's assets, livelihoods, or quality of life. Full compensation/ mitigation unlikely. Health effect or injury causing permanent disabilities/fatalities.	Multiple locations within the Study Area; more than 40 persons affected. Extensive coverage in local/national media	Longer-term, lasting more than twelve months; permanent effects on people's health/livelihoods
Very High **[5]**	***Massive*** impact on quality of life, living standards, and/or livelihood. Multiple fatalities. Social conflict resulting from actual/perceived Project activities leading to violence threatening the lives of workers/community	Extensive impact on population across the Study Area and wider geographic zone; more than 60 persons affected. Extensive coverage in local/national/ regional media	Long-term; permanent/ irreversible impacts on health/livelihood. Loss of lives/chronic illness.

6.12.2 Summary Social Impacts

Prior to the evaluation of social impacts as per criteria outlined in Table 6.18 above, the potential impacts as perceived by the PAPs and identified through analyses are summarized in Table 6.19.

Table 6.19: Socio-economic Impact Categories, Indicators, and Nature of Impact.

Impact Category	Impact Issue/Indicator	Nature of Impact (Positive or Negative)
Community Governance, Cohesion and Organization	✓ Governance and Participation	The Road Project stands to positively impact on community governance by contributing to improved public confidence among and between local and central level government and community residents, especially in communities like Sandhill where political polarization and exclusion due to partisan politics are pronounced. Early engagement and participation of village councils and residents of communities within the Study Area has contributed to engendering a process of inclusion and participation. Village councils and for the most part residents have expressed appreciation in being consulted on the proposed road rehabilitation; notwithstanding, a small number of residents have been hostile and out rightly refused to participate in the early engagement and consultations activities, particularly in the Ladyville Area. Outside the duly elected village councils, organized religious and political groupings, community organization is not common. The community of Gardenia has shown evidence of an organized women's group in the past but it is no longer active.
	✓ Access to decision-making	The right of community residents to know, participate and potentially influence the Road Project decision-making processes and protect their community interests is contributing positively; this positive impact is highly correlated with the extent, quality and effectiveness of the ongoing community engagement and consultation process. With the exception of Sandhill Village, the area representative and central government are easily accessible and supportive. Notwithstanding, decision-making is highly centralized and usually non-participatory and non-inclusive; where participation/inclusion is sought, it is traditionally of a partisan political and transactional nature. Active community participation and access to decision making is not the norm in community projects, which are usually top down in their approach. The general exception in the affected communities is in relation to SIF projects, which are underpinned by community inputs via participatory appraisal methodology.
Services and Community Resources	✓ Recreation, Parks and Playground	The communities of Ladyville, Lord's Bank, and Sandhill reflect better recreational resources compared to Gardenia and Biscayne. To this end, these communities engage in far more intra- and inter-community sporting activities. It is expected that the proposed Road Project will positively impact on these recreational activities by attracting increased visitors from Belize City and neighbouring communities given the reduced travelling time and improved road safety.
	✓ Water and Sewage infrastructure	BWSL water mains across the road sections are located within the road reserve; as such, these are completely exposed. To this end, planned service interruptions may be unavoidable and access to water services may be negatively impacted during the construction phase. Outside of the planned water interruptions, sewage disposal (flushed toilets to septic) are not anticipated to be impacted by the Project across the Road Sections.
	✓ Electricity infrastructure	In many instances, electric poles fall within the road reserve across the road sections. Planned service interruptions may be unavoidable and access to electricity services may be negatively impacted during the construction phase.
	✓ Public Transport and Road Use	Construction vehicles may put pressure on and negatively impact the public transport and road system across the Project Area; access routes for

			pedestrians, cars, buses, and trucks could be impeded by construction vehicles thereby increasing travel time for school, work, and business. Additionally, existing bus stops fall within the existing road reserve and would need to be demolished and rebuilt with proper bus pull-offs. In the operation phase however, positive benefits are expected with the proposed road upgrade, inclusive of modern road design and dressings.
	✓	Education Infrastructure and Service	The Road Project either could positively or negatively impact education infrastructure and service. With the upgrade of the road sections, comes improved road safety for pedestrians with special attention to school children given the proximity of the existing road to schools in the communities of Ladyville, Sandhill, and Biscayne; with modern design and strict safety standards and enforcement, the road project is expected to positively impact on school safety. Additionally, dust and noise from construction and increased traffic flow from transportation of materials could adversely impact on educational services along the road sections.
	✓	Health Infrastructure and Service	Except for the communities of Ladyville and Lord's Bank, who now share an improved health polyclinic, limited health infrastructure exist across the remaining communities. Given that many residents seek health services from Belize City, it is anticipated that the Road Project may adversely impact on this service due to increased travelling time during road construction; in the long term, however it is expected to positively impact given reduced travelling time and improved road safety.
	✓	Citizen Security and Crime	Outside of Ladyville Village, police presence and substations/precincts/ outposts are limited. Communities are generally described as being safe with low levels of reported criminal activity; the relative exception being Ladyville with higher levels of reported homicides, domestic violence, and burglaries. It is expected that the road project will positively impact on the situation of crime and citizen security given increased police response time for communities neighbouring to Ladyville. On the flip side, the improved road conditions could also negatively impact due to increased presence of and reduced travelling time for the criminal elements.
Health	✓	Health problems related to pollution	The Road Project stands to positively impact pollution related health problems in the long term due to reduced dust; however, it may negatively impact during the construction phase.
	✓	Communicable disease	Influx of external labour force for the road project may increase exposure to communicable diseases, viz STI/HIV.
	✓	Injury	Construction, transport, and operations could expose workers, residents and other road users to increased RTAs and injuries.
	✓	Occupational Health	The Road Project may positively or negatively impact on the occupational health of workers/road users. By contractors adhering to OSH standards, the occupational health of workers, residents, and road users can be positively impacted via a culture of improved road safety practices. However, where these standards are not enforced/complied with, significant negative impact can be experienced inclusive of serious injury and/or loss of life.
Socio-Demographic Characteristics	✓	Population: Structure and In-migration	No impact on the population structure is projected in the short-term; however, job-seeking in-migration may negatively impact social and cultural aspects of communities due to differences in socio-cultural lifestyles particularly for communities beyond Ladyville.
	✓	Social cohesion	Social cohesion within and among communities along the road sections could be adversely impacted by differential access to Project opportunities and influx of Project workers.
	✓	Poverty/vulnerability and social exclusion	Project costs and benefits could either serve to reduce or increase the vulnerability of specific groups of affected persons(women, youth, children) in the short-term thus having either a positive or negative impact dependent on how these costs and benefits are borne/accrued/distributed. Special attention to equity and special quotas for women and youth are strongly recommended. Zero tolerance to child labour will be practiced.
Cultural Heritage	✓	Archaeological sites/mounds/points of interests	The Road Project has the potential to positively impact on Mayan sites and protected areas in neighbouring communities (Burrell Boom, Crooked Tree, and Rockstone Pond) through reduced travelling time and improved access for tourists/travellers resulting in increased opportunities for

			livelihoods and overall added economic benefits/development of rural Belize District. No sites were readily identified via the Archaeological Assessment within the road corridors; to this end, the Project is not expected to impact on any known sites; however, all necessary mitigation measures will be taken during the construction phase to remove the potential for any negative impact on unknown sites.
	✓	Cemeteries	Cemeteries managed by the respective village councils are outside the immediate zone of impact of the road project; to this end, the proposed road project is not expected to impact on existing cemeteries.
	✓	Art Centre	A small art centre, 'Sandhill Art Center', is operated just on the outskirts of the Village (Mile 19 ¼) and given its location within/in close proximity to the road reserve may be adversely impacted by the road project. To this end, demolition, temporary relocation, and reconstruction will be necessary to preserve the supported activities (details to be defined in the RAP report).
Involuntary Displacement	✓	Temporary/ Permanent Land Take and Loss of Livelihood	While the footprint of the proposed roadway is not anticipated to significantly diverge, horizontal alignments in limited instances with respect to identified curves at miles 17, 18 and 19 and the introduction of three (3) roundabouts for improved traffic control as proposed in the feasibility study may become necessary and will affect existing property lines. Additionally, temporary land take may also occur where land will be acquired for contractor's camps, gravel pits and hard stone quarries. Generally, however upgrading of the road is expected to cause minimal adverse impact since the Project is designed in such a way that minimal private land is to be affected. Additionally, and particular during the construction phase changes to lifestyles and livelihood activities for a small number of roadside vendors who operate within the roadway reserve will occur as specified in the ESBA while residents will also be affected by construction activities including disturbance and increased pressure on resources and services. Detailed descriptions of impacted persons and properties, preliminary consultations and recommended actions to be detailed in RAP report.
Economic Environment	✓	Costs of goods and services and socio-economic development	It is not anticipated that the influx of Project workers will impact the cost of basic goods and services (inflation); the Project is however, expected to positively impact the socio-economic development and wider economic development of communities along the road sections in the medium to long-term through improved access to markets, safety, and security and increased tourism.
Employment, Livelihoods and Income Generating Activities	✓	Employment and Skills	Employment is a potential positive impact of the Project, directly through employment on the Project and indirectly through livelihoods. Poor governance practices relating to sourcing of labour and lack of/limited skills however pose challenges job access, which could be a negative impact. Project employment and training could positively impact the local skills base.
	✓	Development of business and informal livelihood activities.	It is anticipated that the Project will positively impact on potential business development and livelihood activities in the medium to long term given ease of access and reduced travelling time; however, in the short term these may be adversely affected due to road construction activities.

6.12.3 Potential Impacts and Proposed Mitigation Measures

This section analyses perceived impacts along with those identified on the basis of observation, consultation, and the baseline survey. The discussions summarize impacts by respective 'impact category' using specified social indicators; the significance of each impact, recommended mitigation measure/s and significance of each impact after mitigation (residuals) is presented.

6.12.3.1 Governance, Cohesion and Organisation

Potential Impact Issues

Community Governance/Participation/Social Cohesion: The Road Project stands to positively impact on community governance by contributing to improved public confidence among and between local and central level government and community residents, especially in communities like Sandhill where political polarization and exclusion due to partisan politics are pronounced. Early engagement and participation of village councils and residents of communities within the Study Area has contributed to engendering a process of inclusion and participation. Village councils and for the most part residents have expressed appreciation in being consulted on the proposed road rehabilitation; notwithstanding, a small number of residents have been hostile and out rightly refused to participate in the early engagement and consultations activities, particularly in the Ladyville Area. Outside the duly elected village councils, organized religious and political groupings, community organization is not common. The community of Gardenia has shown past evidence of an organized women's group; however, it is no longer active.

Access to Decision-Making: The right of community residents to know, participate and potentially influence the Road Project decision-making processes and protect their community interests is contributing positively; this positive impact is highly correlated with the extent, quality and effectiveness of the ongoing community engagement and consultation process. With the exception of Sandhill Village, the area representative and central government are easily accessible and supportive. Notwithstanding, decision-making is highly centralized and usually non-participatory and non-inclusive; where participation/inclusion is sought, it is traditionally of a partisan political and transactional nature. Active community participation and access to decision making is not the norm in community projects, which are usually top down in their approach. The general exception in the affected communities is in relation to SIF projects, which are underpinned by community inputs via participatory appraisal methodology

In both the construction and operations phases, a potential impact may be the improvement or continued exclusion of women and men from access to decision-making about development projects in their area. Up until recent time, it has not been the norm for residents to be consulted on projects in their area. The approach to stakeholder engagement and the wider public participation process therefore has presented a great opportunity for positively impacting on the current lack of access to decision-making, by improving means for local people to participate and potentially influence the Project decision making process (and for continued consultation beyond the ESIA Study phase and via a grievance mechanism), or negatively, by raising expectations on access to decision-making and then failing to deliver – which could then have further implications for the wider social risk context of the Project.

To This end, the Project also serves to strengthen governance relationships and restore strained confidence among and between central and local governments. Often, promises of development projects are context within political campaign promises and hardly ever materialize thereafter; however, subject to the feasibility studies, the Road Project may stand to demonstrate that the upgrade of the road sections of the PGH is in fact substantive.

As a result, in both the construction and operation phases, the Project is likely to have highly significant impacts on the standing, capacity, coverage, and support for/of the village councils. These impacts could be positive, if MOW (through its agents) works with the village councils who are committed to being inclusive of all groups within their communities as opposed to those that merely seek to serve partisan interests, and further marginalize the vulnerable.

Significance

As the PAPs are not generally used to being consulted it is rather difficult to assess the significance of risk of the potential positive or negative impacts of the consultations on social cohesion; early indications coming out of the focus group discussions and socio-economic survey are that PAPs have welcomed MOW's approach to early sharing of information, consultations and engagement with respect to the Road Project. The true test however, will be in the "eating of the pie" to see how well community concerns are addressed by the Project and the level of confidence generated as a consequence, or vice versa. To this end, the Participatory Public Participation Process (PPP) serves as an important barometer in this regard.

Mitigation Measures

It is recommended that MOW remains committed to continued consultation through to the construction phase, to ensure that it works with representative community organizations like the village councils and contractors who are required to be open to the hiring of socially marginal groups/under-represented groups (women and youth) for broader based Project support.

Additionally, service contracts for maintaining the rehabilitated GPH could be explored with the village councils across Road Sections to strengthen ties between local and central government and demonstrate tangible commitments with respect to ensuring the hiring of locals with special quotas for women and youth.

Additionally, continued engagement and consultations with communities beyond the ESIA study phase is recommended; furthermore, the implementation of a community grievance mechanism during construction and early operations phase of the road project is also recommended

Evaluation after Mitigation

Given effective design and implementation of the PPP guidelines, the impacts on access to decision-making and community representation would be generally positive; while it is not anticipated that one positive experience will reverse the 'general lack of confidence/trust' in public authorities, it certainly can contribute. There are already early signs that consultation has contributed to some good relationship building with residents and village councils across the Study Area, and it is further anticipated that the upcoming public consultations will only serve to strengthen this.

6.12.3.2 Services and Community Resources

Potential Impact Issues

Recreation and Leisure: The communities of Ladyville, Lord's Bank, and Sandhill reflect better recreational resources compared to Gardenia and Biscayne. To this end, these communities engage in far more intra- and inter-community sporting activities. It is expected that the proposed Road Project will positively impact on these recreational activities by attracting increased visitors from Belize City and neighbouring communities given the reduced travelling time and improved road safety.

Water and Sewerage Infrastructure: BWSL water mains across the road sections are located within the road reserve; as such, these are completely exposed. To this end, planned service interruptions may be unavoidable and access to water services may be negatively impacted during the construction phase.

Outside of the planned water interruptions, sewage disposal (flushed toilets to septic) are not anticipated to be impacted by the Project across the Road Sections.

Electricity Infrastructure: In many instances, electric poles fall within the road reserve across the road sections. Planned service interruptions may be unavoidable and access to electricity services may be negatively impacted during the construction phase.

Public Transport and Road Use: These are concerns for many members of affected communities; e.g., participants in focus group discussions stated that "the problem will get more complicated"; "traffic will get worse, especially with public transportation"; "our kids will be late for school and we may get late to and from work". The Project will also rely on a significant number of transport vehicles, both for the transport of Project equipment and for Project staff, which may contribute to traffic congestion on roads further exacerbating issues of increased travelling time for students and workers. To this end, Construction vehicles may put pressure on and negatively impact the public transport and road system across the Project Area; access routes for pedestrians, cars, buses and trucks could be impeded by construction vehicles thereby increasing travel time for school, work, and business. Additionally, existing bus stops fall within the existing road reserve and would need to be demolished and rebuilt with proper bus pull-offs. In the operation phase however, positive benefits are expected with the proposed road upgrade, inclusive of modern road design and dressings.

Education Infrastructure and Service: the Road Project either could positively or negatively impact Education infrastructure and service. With the upgrade of the road sections, comes improved road safety for pedestrians with special attention to school children given the proximity of the existing road to schools in the communities of Ladyville, Sandhill, and Biscayne; with modern design and strict safety standards and enforcement, the road project is expected to positively impact on school safety. Additionally, dust and noise from construction and increased traffic flow from transportation of materials could adversely impact on educational services along the road sections. It is not anticipated that the potential influx of job seekers, or Project workers moving to the area would place any additional strain on the infrastructure since it is not anticipated that significant numbers of workers are likely to move to the Project affected communities with their families.

Health Infrastructure and Service: Except for the communities of Ladyville and Lord's Bank, who now share an improved health polyclinic, limited health infrastructure exist across the remaining communities. Given that many residents seek health services from Belize City, it is anticipated that the Road Project may adversely impact on this service due to increased travelling time during road construction; in the long term, however it is expected to positively impact given reduced travelling time and improved road safety.

Citizen Security and Crime: Outside of Ladyville Village, police presence and substations/precincts/outposts are limited to non-existent. Communities however, are generally described as being safe with low levels of reported criminal activity; the relative exception being Ladyville with higher levels of reported homicides, domestic violence, and burglaries. It is expected that the road project will positively impact on the situation of crime and citizen security given increased police response time for communities neighbouring to Ladyville. On the flip side, the improved road conditions could also negatively impact due to increased presence of and reduced travelling time for the criminal elements.

Significance

It is anticipated that Project impacts on electricity and water infrastructure and service will be low to moderate; impacts on transport infrastructure could be moderate, especially during the construction phase, when there will be many trips a day during peak periods.

Impacts on pedestrian and road access to communities could be moderate, increasing commuting time for local residents and thus affecting livelihoods, and presenting a problem for emergency vehicle access to communities. Project impact on education and health infrastructure and service is expected to be low to medium and on citizen security and crime, moderately positive.

Mitigation Measures

MOW is committed to using appropriate construction mitigation measures and due diligence to ensure that people will not be negatively impacted. Thus the location/re-location of the electric poles/lines and water lines will be well coordinated actions with service providers and due notification/effective communication to affected House Holds (HHs) will be provided.

Implement effective traffic management practices as a key component of the overall Safety Plan. Provide timely information to residents/road users through the media about upcoming construction works, expected duration of the works, alternative routes, etc.

MOW to ensure road project considers replacement/construction of bus stops with appropriate pull-offs across communities in ROW.

Implementation of dust and noise suppression measures, particularly in populated and school zones will be implemented by agents of MOW (contractors) during the construction phase.

Evaluation after Mitigation

Residual impact on water and electricity infrastructure and services will be very low; however, stress on public transport and transport infrastructure remains moderate despite proposed mitigation measures due to limited influence the Project can have on the transport systems infrastructure. Impact on education and health infrastructure and services will be reduced to low significance.

6.12.3.3 Socio-Demographics

Potential Impact Issues

Population: Structure and In-Migration: Strong recommendation to source workers locally is proposed; notwithstanding, due to the lack of appropriate skilled labour in the area there is the reality that workers may have to be sought from outside the Project Area. There are risks related to in-migrant populations discussed further below in terms of social cohesion and inclusion and in terms of health impacts of communicable disease. Furthermore, the already male skewed population structure may change further to include even more males of working age. The influx of workers, impact on social cohesion by introducing new/different demographics into these established communities inclusive of concerns by residents of sexual harassment of women and sexual exploitation of adolescent girls by a predominantly male work force require due attention.

Social Inclusion: The Road Project is one of few projects in Belize, and certainly in the Project Area to include community residents, representatives, and leaders in consultations. In the long run, however, the Project could either decrease/or increase vulnerability depending on the way it makes Project benefits available to the full range of community members, particularly women and children. This is dependent on the effective implementation of the Social Management Plan (SMP) and PPP Guidelines as well as the cumulative impacts of the Project in relation to wider economic development of the Study Area.

Poverty, Vulnerability and Social exclusion Project costs and benefits could either serve to reduce or increase the vulnerability of specific groups of affected persons(women, youth, children) in the short-term thus having either a positive or negative impact dependent on how these costs and benefits are borne/accrued/distributed. Special attention to equity and special quotas for women and youth are strongly recommended.

Child and Adult Protection: The Project has the potential to negatively impact communities as it relates to sexual exploitation of adolescent girls and harassment of women by a predominantly male workforce. Additionally, adopting a zero tolerance on child labour practices by agents of the MOW is recommended.

Significance

Significance is moderate to high as there may be negative impacts of uncontrolled in-migration, as well as spill over protection effects.

Mitigation Measures:

MOW to require contractors to develop policies for workers induction and a socio-culturally appropriate code of conduct for interacting in communities inclusive of training on gender related issues inclusive of sexual harassment of adult females, sexual exploitation of adolescent girls (CSEC), Child Labour and HIV and AIDS training; the latter could be arranged through the Ministry of Human Development, Women's Department.

It is also recommended to make all necessary efforts to source labour from local communities insofar as requisite skills allow with special quota for women and youth to balance the population structure and contribute to vulnerability reduction.

Evaluation after Mitigation

After mitigation, the significance remains very low to low, given that most of the potential impacts of the Project on socio-demographics are outside the control of Project managers. However, good social policies have the desired effect of reducing negative impacts and enhancing the positive; to this end the code of conduct and training become appropriate measures to further mitigate the identified impacts.

6.12.3.4 Cultural Heritage

Potential Impact Issues

Archaeological Sites, Mounds, and Points of Interests: The Road Project has the potential to positively impact on Mayan sites and protected areas in neighbouring communities (Burrell Boom, Crooked Tree, and Rockstone Pond) through reduced travelling time and improved access for tourists/travellers resulting in increased opportunities for livelihoods and overall added economic benefits/development of rural Belize District.

No sites were readily identified via the Archaeological Assessment within the road corridors; to this end, the Project is not expected to adversely impact on any known sites; however, all necessary mitigation measures will be taken during the construction phase to remove the potential for any negative impact on unknown sites.

Cemeteries: Cemeteries managed by the respective village councils are outside the immediate zone of impact of the road project; to this end, the proposed road project is not expected to have any impact on existing cemeteries.

Art Centre: A small art centre, 'Sandhill Art Center', is operated just on the outskirts of the Village (Mile 19 ¼); given its location within the road reserve, it will be adversely impacted by the Project. To this end, demolition, temporary relocation, and reconstruction will be necessary to preserve the supported activities (details to be defined in the RAP report).

Significance

Archaeological points of significance are not known to be located in the wider Study Area and as such, the Project is not expected to have any adverse impact. Given the overall positive contributions to tourism development however, overall significance is rated as positively moderate.

Additionally, significance on the Art Center is expected to be moderate.

Mitigation Measures

Given that road construction material may be mined from within the wider study area and surrounding environs, then as a general precautionary measure, the services of the Institute of Archaeology should be enlisted to survey these areas to determine if there are in situ archaeological materials or sites. If such materials are found, then such quarries should be eliminated from use as borrow pits, or the archaeological sites should be salvaged/mitigated prior to their removal.

With respect to the 'Art Centre', recommendation to provide a temporary relocated structure and subsequently reconstruct the Art Centre (with pre-planning, relocation/reconstruction can precede actual road construction works in Sandhill to minimize disruption to livelihood and artistic expression)

Evaluation after Mitigation

Risk after mitigation will be very low.

6.12.3.5 Health Impacts Resulting from Pollution

Potential Impact Issues

The key health problems identified during the baseline study and focus group discussions relate primarily to chronic illnesses (diabetes, hypertension, etc.) and to some degree respiratory health issues (dry cough, difficult breathing, chest wheezing/asthma) and thus the valued receptors most at risk from negative impacts are those already vulnerable to respiratory problems e.g. school children, asthmatic children/adults, smokers and the elderly. From the Focus Group discussions it is clear that the PAPs consider there is a high risk of the Project contributing to air pollution and thus causing further health risks in the short-medium term. Asthmatic children may be significantly negatively impacted by increase in dust. Pollution (quality of life associated with environment conditions) is the major respiratory health risk factor raised by the local communities; however, in the end, the Road Project stands to positively impact pollution related health problems due to reduced dust from improved road surfacing and maintenance.

Significance

The impacts of the Project on pollution related health problems are moderate during construction, especially for susceptible VRs (those with existing respiratory problems, children, and women who spend most of the day at home). The impacts during the operational phase are considered moderately positive.

Mitigation Measures

During the construction phase, a rigorous health and safety plan will be implemented to ensure excavation and construction activities minimize dust and noise-related pollution for the workforce, neighbouring communities and schools. Mitigation Measures will be clearly communicated to the PAPs to reduce stress caused by uncertainty.

Evaluation after Mitigation

The significance of pollution impacts on health after mitigation measures would be very low for operational and construction impacts.

6.12.3.6 Health Impacts: Communicable Diseases

Potential Impact Issues

Employment opportunities may attract in-migration to the Project Area as well as use other workers. Thus, there may be associated negative impacts to health of PAPs due to transfer of disease (STI/HIV). Hygiene and health problems on the construction site may be caused by pools of standing water, which may create habitats for insect disease vectors such as eye infection and Zika. Additionally, the baseline survey showed extremely low levels of comprehensive knowledge of HIV and AIDS, which further contributes to the potential for increased transmission.

Significance

The significance of increased exposure to communicable disease is difficult to assess at this point, as the strategy for hiring workers has not yet been defined. Notwithstanding, the Project may likely exacerbate the situation on HIV/AIDS and Sexually Transmitted Infections (STIs) due to workforce that will be away from home and has higher disposable income. There may also be possible impact of immigrant workers who would bring social disruption of communities where construction campsite and accommodation will be located which can lead in some cases to marriage/family breakups during the construction period. This is exacerbated if construction workforce is brought from elsewhere. There could also be increased drug and alcohol abuse mainly during construction period and communicable diseases (food and water-borne) and road traffic construction related accidents. Given the population sizes of the communities and the low levels of comprehensive knowledge of HIV-AID and literacy levels, it is anticipated that the contribution of the Project to communicable disease will be moderate to high.

Mitigation Measures:

The MOW through the Project Management Unit (PMU) and its contractors are required to implement HIV/AIDS awareness, prevention, and control activities aimed at construction workers and the communities in the Project Area in line with the Environmental and Social Management Plan.

Additionally good hygiene and health practices in line with the overall health and safety plan are to be observed.

Evaluation after Mitigation

With mitigation measures in place the impact of the Project on the levels of communicable diseases in communities and amongst Project workers and their families, should be low to moderate.

6.12.3.7 Health Impacts: Injury and Accidental Health Damage

Potential Impact Issues

Project activities, in particular construction, transport, and operations activities, may expose workers, residents and other road users to increased RTAs and injuries.

Occupational Health: Transport vehicles and traffic in the area could expose both workers and residents to the risk of traffic accidents. Community members are concerned about the possibility of accidents and emergencies. Thus, there is a risk of small scale but potentially occasional traffic and construction accidents and less frequent but potentially larger scale operations accidents both of which could impact on the health and safety of workers and local communities. This concern is further exacerbated by the limited emergency services and access to these services along the ROW.

Construction and operational activities could expose workers to health and safety risks. In particular, the following activities could have negative health impacts: noise and dust from demolitions and excavations (stress, ear and eye problems); working with heavy equipment (strains and accidents); heavy lifting, and working under noisy conditions (hearing and stress/psychological impacts). Excavations and transportation of materials may cause further health and safety negative impacts. Occupational health and emergency health services for the construction labour force will be at risk of negative health impacts, which cannot be quantified, until clear plans emerge. The need for an on-going, proactive workers health and safety plan applies for the full life cycle of the Project.

To this end, the Road Project may positively or negatively impact on the occupational health of workers/road users. By contractors adhering to the OSH Bill recommended standards, the occupational health of workers, residents, and road users can be positively impacted via a culture of improved road safety practices. However, where these standards are not enforced/complied with, significant negative impact can be experienced inclusive of serious injury and/or loss of life.

Significance

Risk of accidents from construction and operations is of moderate significance, in particular risk of accidents from increased traffic. In the absence of an operational/fully functional Health and Safety plan and health training for workers the risks of worker health and safety are high.

Mitigation Measures

While a major incident may be improbable, the nature of activities in the Area means the development, communication and implementation of a robust Preparedness Plan are essential for both local communities and workers. Health care providers should be consulted in developing this plan;

Develop traffic control measures to limit the risk of construction, operational and transport accidents, which could endanger the health of community members;

Conduct a road safety campaign and enforce traffic safety laws to reduce the risk of traffic related accidents during the construction and operational phases of the upgraded road.

MOW to require contractors to adopt strict construction and operation practices (Health and Safety Plan) with best technology and health and safety training to ensure the safety of its workers and all road users. In line with the OSH Bill proposed standards.

Evaluation after Mitigation

Due to the impossibility of completely safeguarding against unanticipated accidents, specifically traffic accidents, significance after mitigation will be reduced from moderate to low. With occupational health protection in place, significance of risk of damage to health is also reduced to low.

6.12.3.8 Involuntary Displacement

Potential Impact Issues

Temporary/Permanent Land Take and Loss of Livelihood: While the footprint of the proposed roadway is not anticipated to significantly diverge, horizontal alignments in limited instances with respect to identified curves at miles 17, 18 and 19 and the introduction of three (3) for improved traffic control as proposed in the Feasibility Study may become necessary and will affect existing property lines. Additionally, temporary land take may also occur where land will be acquired for contractor's camps, gravel pits and hard stone quarries. In generally, however, upgrading of the road is expected to cause minimal adverse impact since the Project is designed in such a way that minimal private land is to be affected.

Additionally, and particular during the construction phase changes to lifestyles and livelihood activities for a small number (twenty estimated) of roadside vendors who operate within the roadway reserve will occur as specified in the ESBA while residents will also be affected by construction activities including disturbance and increased pressure on resources and services.

Detailed descriptions of impacted persons and properties, preliminary consultations and recommended actions to be detailed in RAP Report.

Significance

Given the potential impacts of the horizontal alignments and proposed roundabouts combined with impacts on livelihoods, significance is rated as moderate.

Mitigation Measure

Where private land take is absolutely unavoidable, market-value compensation to owners will be employed after due consultation process managed by the MOW and as defined and agreed to in the RAP and in tandem with the World Bank safeguards.

Effective and constant communication and due lead time will be given to vendors with support for relocation;

Evaluation after Mitigation

Residual impact is anticipated to be low.

6.12.3.9 Economic Environment

Potential Impact Issues

Perceived Economic Development: The Project could have both positive and negative impacts on the economic environment. This mix was reflected in the perceptions of community members of the potential economic impact of the Project. Respondents engaged in income-generating activities thought there would be positive impacts on the local economic development with respect to improved cultural and nature-based tourism with secondary effects from improved security presence in the Study Area.

National Economic Development: The Project will also contribute positively on the development of the national economy. During the life of the Project, the Government will realize significant revenues, taxes, and customs duties; furthermore, it will engage Belizean contractors and sub-contractors thus promoting national GDP growth. Construction material may also be purchased from the surrounding area.

Local Economic Development: In communities across the Road Sections, there was the perception that the Project would lead to positive impacts on local economic development due to increased traffic flow and greater influx of tourists in the area. Positive influences on local economic development could derive from job opportunities for local residents; and multiplier effects on local ancillary services (local restaurants, shops, transport). The Project could have both negative and positive influences on socio-economic development in communities. Negative influences may derive from increased inequality (perceptions of) between vulnerable groups and Project employees.

Cost of Goods and Services: The purchase of local goods and services by the construction labour force (e.g. use of local shops and restaurants, and accommodations) could potentially lead to positive impacts. Positive impacts include creating local economic development and employment. As the Project is located across a populated rural/peri-urban area characterized by many demographic and economic processes it is unlikely that local inflation could be attributed to the Project.

Significance

Overall significance is rated as moderately positive.

Mitigation Measure

The MOW will take into account the socio-economic baseline context and require of its contractors, consultations with village councils as it relates to employment.

6.12.3.10 Employment, Livelihoods and Income Generation

Potential Impact Issues

Employment and Skills: Employment is a potential positive impact of the Project, directly through employment on the Project and indirectly through livelihoods. Poor governance practices relating to sourcing of labour and lack of/limited skills however pose challenges to job access, which could be a negative impact. Project employment and training could positively impact the local skills base.

Access to Project Employment: This is a key priority for PAPs across the Road Sections, which is not surprising given the levels of under-development and unemployment as revealed by the socio-economic baseline survey and poverty mapping data, SIB (2012).

While there was an expectation across the affected communities that the Project would lead to job opportunities for local people, this was tempered by concerns about real access for local people to Project employment. A major concern across all communities relates to poor governance practices (corruption and nepotism) with the belief that locals lack the connections to get jobs and that, contractors would normally bring in their own teams. Another concern was that local people would lack the skills to get jobs on the Project. This was a particular concern among youth and women.

In the light of these concerns about whether local people would actually be able to access Project jobs, there was the attitude amongst some community members that Government's commitment to providing jobs for local people is only propaganda and will not be fulfilled in practice

Gender: In terms of equal opportunities for accessing Project employment, while many community members do not believe that Project job opportunities will reach all sections of the community, in some cases there was the belief that new job opportunities could benefit youth, and would include women and poor people in the area. In fact, access to Project employment may be more problematic for some valued receptors such as women. In particular, unless equal opportunities are promoted, it may be more difficult for women to access employment opportunities as many of the jobs are in male stereotyped professions and because of local social attitudes towards women working in road works projects.

Vulnerable Groups: In particular residents with low literacy level may also have trouble accessing job opportunities if they are advertised in written media compounded by the fact that they also lack the skills base needed by the Project and opportunities to upgrade skills may be outside the immediate scope of the Road Project, unless an on the job training component is integrated.

Skills Development: Project investment in skills development for construction could increase the employability of locally recruited workers in the long term by upgrading skills bases to standards required by the construction industry. If workers are trained to take some of the jobs, there is medium potential this could contribute to social development in the long term.

Informal Livelihood Activities: A number of small businesses and women and men engaging in informal livelihood activities could be affected by the Project. Businesses in the right of way include road vendors selling food, fruit, and vegetables. Many believe that increased Project traffic and the presence of workers will be a positive impact for their businesses. However, it is also possible that, unless managed appropriately, increased congestion and pollution from traffic/dust could negatively impact these businesses.

Significance

In both construction and operational phases of the Project, there is an opportunity for maximizing positive impacts on local employment through involving unskilled (and where possible skilled) labour from all Project communities. However, although the generation of employment opportunities resulting from Project activities is expected as a positive impact, there is a risk that conflicts could arise between local residents and new comers or outsiders over such employment opportunities. Furthermore, there is high risk that, unless Project employment and contractors are managed appropriately, the recruitment procedure could be less than transparent, meaning that people without connections would not get access to Project opportunities – namely employment and other livelihood benefits. This could lead to a low-moderate risk of social conflict.

Mitigation Measures

The MOW and contractors will work actively to promote local access to Project employment in both the construction and the operations phases. To do this MOW and contractors will apply transparent and fair employment policies and work with local village councils to source local labour.

Additionally, constant communication and due lead time will be given to vendors with support for relocation in the interim; where private land take is absolutely unavoidable, market-value compensation to owners will be explored after due consultation process managed by the MOW.

Evaluation after Mitigation

With effective implementation of the recommended mitigation measures, designed to ensure that skills development and Project employment are accessible to local people, the risk could be reduced to low. However, the fact that much of this work will have to be carried out by contractors and sub-contractor presents a level of uncertainty. In addition, even if a high proportion of Project jobs do go to local people, this cannot make a significant positive impact on local livelihoods, given the population sizes and levels of unemployment in Project affected communities. Given the high level of expectations about Project employment in local communities described above risk remains low-moderate, even after mitigation.

Table 6.20 gives a Summary Impacts, Significance, Mitigation, and Residuals.

Table 6.20: Summary Impacts, Significance, Mitigation, and Residuals.

Impact Category	Impact	Social Receptors	Nature ±	Magnitude [1 ↔ 5]	Extent [1 ↔ 5]	Duration [1 ↔ 5]	Significance [1 ↔ 5]	Proposed Mitigation/ Means to Enhance Positive Impacts	Significance After Mitigation
Community Governance, Cohesion and Organization	**Community Governance and Participation:** The Road Project stands to positively impact on community governance by contributing to improved public confidence among and between local and central level government and community residents, especially in communities like Sandhill where political polarization and exclusion due to partisan politics are pronounced. Early engagement and participation of village councils and residents of communities within the Study Area has contributed to engendering a process of inclusion and participation. Village councils and for the most part residents have expressed appreciation in being consulted on the proposed road rehabilitation; notwithstanding, a small number of residents have been hostile and out rightly refused to participate in the early engagement and consultations activities, particularly in the Ladyville Area. Outside the duly elected village councils, organized religious and political groupings, community organization is not common. The community of Gardenia has shown past evidence of an organized women's group; however, it is no longer active.	Project affected persons (women and youth), local and central governments	**(+)**	2	2	3	2	Continued consultation by MOW to ensure continued engagement with community leadership via the village councils and contractors who are open to hiring of socially marginal/under-represented groups, inter alia women and youth. Post construction phase, explore service contracts with the village councils across Road Sections for road maintenance to strengthen ties between local and central government and demonstrate tangible commitments with respect to ensuring the hiring of locals with special emphasis on women and youth	+
	The right of community residents to know, participate and potentially influence the Road Project decision-making processes and protect their community interests is contributing positively; this positive impact is highly correlated with the extent, quality and effectiveness of the ongoing community engagement and consultation process. With the exception of Sandhill Village, the area representative and central government are easily accessible and supportive. Notwithstanding, decision-making is highly centralized and usually non-participatory and non-inclusive; where participation/inclusion is sought, it is traditionally	Project affected persons, local (village councillors) and central government (area representatives)	**(+)**	3	3	2	4	Continued engagement and consultations with communities beyond the ESIA study phase; implementation of community grievance mechanism during construction and early operations phase of the road project	+

	of a partisan political and transactional nature. Active community participation and access to decision making is not the norm in community projects, which are usually top down in their approach. The general exception in the affected communities is in relation to SIF projects, which are underpinned by community inputs via participatory appraisal methodology.								
Services and Community Resources	**Recreation, Parks and Playground:** The communities of Ladyville, Lord's Bank, and Sandhill reflect better recreational resources compared to Gardenia and Biscayne. To this end, these communities engage in far more intra- and inter-community sporting activities. It is expected that the proposed Road Project will positively impact on these recreational activities by attracting increased visitors from Belize City and neighbouring communities given the reduced travelling time and improved road safety.	Sports enthusiasts, micro-enterprises and wider communities linked by the PGH road sections	+	2	2	3	2	Effective management of the road project	+
	Water and Sewage Infrastructure: BWSL water mains across the road sections are located within the road reserve; as such, these are completely exposed. To this end, planned service interruptions may be unavoidable and access to water services may be negatively impacted during the construction phase. Outside of the planned water interruptions, sewage disposal (flushed toilets to septic) are not anticipated to be impacted by the Project across the Road Sections.	BWS and PAPs/HHs along existing ROW across Road Sections	**(-)**	3	2	2	2	MOW is committed to using appropriate construction mitigation measures as earlier noted and due diligence to ensure that people will not be negatively impacted. Thus, the location/re-location of the water mains will be planned and coordinated with the service provider and due notification to affected HHs will be provided.	1
	Electricity Infrastructure In many instances, electric poles fall within the road reserve across the road sections. Planned service interruptions may be unavoidable and access to electricity services may be negatively impacted during the construction phase.	BEL and PAPs along existing ROW across Road Sections	**(-)**	3	2	2	2	Re-location of the electric poles/lines mains will be planned and coordinated with the service provider and due notification to affected HHs will be provided.	1
	Public Transport and Road Use: Construction vehicles may put pressure on and negatively impact the public transport and road system across the Project Area; access routes for pedestrians, cars, buses, and trucks could be impeded by construction vehicles thereby increasing travel time for school, work, access to services and business. Additionally, existing bus stops fall	PAPs along existing ROW across Road Sections	**Construction: (-)** **Operation: (+)**	2 4	3 3	3 4	3 4	Implement effective traffic management practices as a key component of the overall Safety Plan. Provide timely information to residents/road users through the media about upcoming construction works, expected duration of the works, alternative routes, etc. MOW to ensure road project considers replacement/construction of bus stops with	1 +

	within the existing road reserve and would need to be demolished and rebuilt with proper bus pull-offs. In the operation phase however, positive benefits are expected with the proposed road upgrade, inclusive of modern road design and dressings.							appropriate pull-offs across communities in ROW.	
	Education/Infrastructure and Service: the Road Project either could positively or negatively impact Education infrastructure and service. With the upgrade of the road sections, comes improved road safety for pedestrians with special attention to school children given the proximity of the existing road to schools in the communities of Ladyville, Sandhill, and Biscayne; with modern design and strict safety standards and enforcement, the road project is expected to positively impact on school safety. Additionally, dust and noise from construction and increased traffic flow from transportation of materials could adversely impact on educational services along the road sections.	School children, teachers and PAPs along existing ROW across Road Sections	**Construction: (-)** **Operation: (+)**	2 4	3 3	3 4	2 4	Use of dust and noise suppression measures across the entire road section, but specifically in populated areas and school zones.	1 +
	Health Infrastructure and Service: Except for the communities of Ladyville and Lord's Bank, who now share an improved health polyclinic, limited health infrastructure exist across the remaining communities. Given that many residents seek health services from Belize City, it is anticipated that the Road Project may adversely impact on this service due to increased travelling time during road construction; in the long term, however it is expected to positively impact given reduced travelling time and improved road safety.	PAPs along existing ROW across Road Sections	**Construction: (-)** **Operation: (+)**	2 4	2 2	2 4	2 4	Effective communication and traffic management measures	1 +
	Citizen Security and Crime: Outside of Ladyville Village, police presence and substations/precincts/ outposts are limited. Communities are generally described as being safe with low levels of reported criminal activity; the relative exception being Ladyville with higher levels of reported homicides, domestic violence, and burglaries. It is expected that the road project will positively impact on the situation of crime and citizen security given increased police response time for communities neighbouring to Ladyville. On the flip side, the improved road	PAPs along existing ROW across Road Sections	**Operations:** **(-)** **(+)**	2 4	2 2	4 4	2 3	-	1 +

	conditions could also negatively impact due to increased presence of and reduced travelling time for the criminal elements.								
Health	**Health problems related to pollution:** The Road Project stands to positively impact pollution related health problems in the long term due to reduced dust; however, it may negatively impact during the construction phase.	PAPs at-risk-of or with respiratory illnesses	**Construction: (-)** **Operation: (+)**	3 4	2 2	3 4	3 3	During the construction phase and in line with the required health and safety plan, the MOW via the contractors is to ensure excavation and construction activities minimize dust and noise-related pollution for the workforce, neighbouring communities and schools. Mitigation measures will be clearly communicated to the PAPs to reduce stress caused by related uncertainties.	1 +
	Communicable diseases:: Influx of external labour force for the road project may increase exposure to communicable diseases, viz. STI/HIV.	PAPs, especially women and adolescent boys and girls	**(-)**	3	2	4	3	The MOW through the PMU and its contractors are required to implement HIV/AIDS awareness, prevention, and control activities aimed at construction workers and the communities in the Project Area in line with the Environmental and Social Management Plan. Additionally good hygiene and health practices in line with the overall health and safety plan are to be strictly observed.	2
	Injury: Construction, transport and operations could expose workers, residents, and other road users to increased RTAs and injuries.	PAPs from communities within the Study Area, general road users and workers	**(-)**	3	2	1	2	Develop traffic control measures to limit the risk of construction, operational and transport accidents which could endanger the health of community members; Develop, implement, and socialize the comprehensive Preparedness Plan as essential for both local communities and workers. Health care providers should be consulted in developing this plan; Conduct a road safety campaign and enforce traffic safety laws to reduce the risk of traffic related accidents during the construction and operational phases of the upgraded road.	2
	Occupational Health: The Road Project may positively or negatively impact on the occupational health of workers/road users. By contractors adhering to OSH standards, the occupational health of workers, residents, and road users can be positively impacted via a culture of improved road safety practices. However, where these standards are not enforced/complied with, significant negative impact can be experienced inclusive of serious injury and/or loss of life.	PAPs from communities within the Study Area, general road users and workers	**(+)** **(-)**	3 2	3 2	4 1	3 2	MOW to require contractors to adopt strict construction and operation practices with best technology and health and safety training to ensure the safety of its workers are in line with the OSH Bill	+ 1

Social ad Demographic Characteristics	**Population: Structure and In-migration:** No impact on the population structure is projected in the short-term; however, job-seeking in-migration may negatively impact social and cultural aspects of communities due to differences in lifestyles particularly for communities beyond Ladyville.	Women, adolescent girls and in general PAPs along existing ROW across Road Sections	**(-)**	3	4	3	3	MOW to require contractors to develop policies for workers induction and a socio-culturally appropriate code of conduct for interacting in communities inclusive of training on gender related issues, sexual harassment of adult females, child labour, sexual exploitation of adolescent girls and HIV and AIDS training; these could be arranged through the Ministry of Human Development. Additionally training for workers and the communities on the mandatory child abuse reporting law should be required. Sourcing local labour force insofar as requisite skills allow with special quota for women and youth. MOW to require contractors to enforce zero tolerance to child labour.	1
	Social Cohesion Social cohesion within and among communities along the road sections could be adversely impacted by differential access to Project opportunities and influx of Project workers.	PAPs along existing ROW across Road Sections	**(-)**	2	3	2	2		1
	Poverty/vulnerability and Social exclusion: Project costs and benefits could either serve to reduce or increase the vulnerability of specific groups of affected persons(women, youth, children) in the short-term thus having either a positive or negative impact dependent on how these costs and benefits are borne/accrued/ distributed. Special attention to equity and special employment quotas for women and youth are strongly recommended. MOW to require contractors to enforce zero tolerance to child labour.	Socio-economically vulnerable groups: women, youth and children (quintiles I, II & III) along existing ROW across Road Sections	**Equity focus: (+)** **Status quo: (-)**	2 2	2 2	3 3	2 2		+ 1
	Child and Adult Protection: The Project has the potential to negatively impact communities as it relates to child labour, sexual exploitation of adolescent girls and sexual harassment of women by a usually predominant male workforce	Adolescent females and women and children from communities along ROW	**(-)**	2	2	3	2		1
Cultural Heritage	**Archaeological sites/mounds/sites of interests:** No sites were readily identified via the Archaeological Assessment within the road corridor; to this end, the Project is not expected to impact on any known sites; however, all necessary mitigation measures will be taken during the construction phase to remove the potential for any negative impact on unknown sites. Additionally, the Road Project has the potential to positively impact on Mayan sites and protected areas in neighbouring communities (Burrell Boom, Crooked Tree, and Rockstone Pond) through reduced travelling time and improved access for tourists/travellers resulting in increased	Archaeological sites/protected areas, tour guides and operators accessing tourism sites and protected areas via the PGH	**(+)**	3	2	4	3		+

	opportunities for livelihoods and overall added economic benefits/development of rural Belize District.								
	Cemeteries: Cemeteries managed by the respective village councils are outside the immediate zone of impact of the road project; to this end, the **proposed road project is not expected to impact on existing cemeteries.**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
	Art Center: A small art centre, 'Sandhill Art Center', is operated just on the outskirts of the Village (Mile 19 ¼) and given its location within/in close proximity to the road reserve may be adversely impacted by the road project. To this end, demolition, temporary relocation, and reconstruction will be necessary to preserve the supported activities (details to be defined in the RAP report).	Artisans from Sandhill Village	**(-)**	4	2	4	3	Provide temporary relocated structure and reconstruct the Art Center (with pre-planning, relocation/reconstruction can precede actual road construction works in Sandhill to minimize disruption to livelihood and artistic expression)	(+)
Involuntary Displacement	**Temporary/Permanent Land Take and Loss of Livelihood:** While the footprint of the proposed roadway is not anticipated to significantly diverge, horizontal alignments and construction of roundabouts in limited instances and as proposed in the feasibility study (conceptual designs) may be necessary and will affect existing property lines. Temporary land take may also occur where land will be acquired for contractor's camps, gravel pits and hard stone quarries. Generally, however upgrading of the road is expected to cause minimal adverse impact since the Project is designed in such a way that minimal land take will be required and affected home/land owners will be minimized. Additionally, and particularly during the construction phase changes to lifestyles and livelihood activities for a small number of roadside vendors who operate within the roadway reserve will occur as specified in the ESBA while residents will also be affected by construction activities including disturbance and increased pressure on resources and services. Detailed descriptions of impacted persons and properties, preliminary consultations and recommended actions to be detailed in RAP report.	Private land/home owners	**(-)**	4	2	4	3	Where private land take is unavoidable, market-value compensation to owners will be employed after due consultation process managed by the MOW and as defined and agreed to in the RAP. Effective and constant communication and due lead time will be given to vendors with support for relocation;	1

Economic Environment	**Costs of Goods and Services and SE Development:** It is not anticipated that the influx of Project workers will impact the cost of basic goods and services (inflation); the Project is however, expected to positively impact the socio-economic development and wider economic development of communities along the road sections in the medium to long-term through improved access to markets, safety and security and increased tourism.	PAPs along existing ROW across Road Sections	**(+)**	2	2	4	3	The MOW will take into account the socio-economic baseline context and require of its contractors, consultations with village councils as it relates to employment inclusive of quotas for women and youth.	+
Employment, Livelihoods and Income Generating Activities	**Employment and Skills:** Employment is a potential positive impact of the Project, directly through employment on the Project and indirectly through livelihoods. Poor governance practices relating to sourcing of labour and lack of/limited skills however may pose challenges to job access, which could be a negative impact.	Men, Women and Youth from PAPs along existing ROW across Road Sections; special attention to youth and women Men,	**(+)** **(-)**	2 2	2 2	2 3	2 2	The MOW and its contractors will work actively to promote local access to Project employment in both the construction and the operations phases. To do this MOW and contractors will apply transparent and fair employment policies and work closely with local village councils to source local labour pool. Additionally, constant communication and due lead time will be given to vendors with support for relocation in the interim; where private land take is absolutely unavoidable, market-value compensation to owners will be employed after due consultation process managed by the MOW and as specified in the RAP and guided by the WB safeguards.	1 +
	Skills Project employment and training could positively impact the local skills base, by enhancing/diversifying skills base of women and youth.	Women and Youth from PAPs along existing ROW across Road Sections	**(+)**	1	1	3	1		+
	Development of Business and informal livelihood activities It is anticipated that the Project will positively impact on potential business development and livelihood activities in the medium to long term given ease of access and reduced travelling time; however, in the short term these may be adversely affected due to road construction activities.	Business establishments and roadside vendors	**Construction: (-)** **Operation: (+)**	2 3	2 2	3 4	2 3		1 +

6.12.4 Social Risks

Despite the mitigation measures being recommended to put in place to reduce negative impacts and enhance positive impacts, the Project potentially faces social risks due to the national and local context in which it will be operating. To complete the impact risk assessment, the social risk context, over which the Project has limited control, is discussed below.

Past Relationship between Government and PAP Communities: Past relationship and experience give rise to a level of mistrust that many local residents have for central governments and to a lesser extent the village councils in the Study Area. These are based on a perception that promises by governments in the past have not been honoured and that local people are generally not the beneficiaries of employment opportunities generated by these development projects*…"so what will be different this time around"*, commented one resident. The risk that this mistrust will continue is high, unless appropriate mitigation through effective consultations and transparent contracting practices involving PAPs are implemented. To this end, effective response to this mistrust requires on-going engagement, consultations, and transparent and effective implementation of agreed social and environmental management measures. Of further significance, and a positive contribution to reducing the identified risk, is the proven track record with development projects that the SIF has across the Project Area and duly recognized by the communities.

Socio-Political Structures that may exclude PAPs from Project Benefits: In addition, a frequent concern expressed by PAPs was that poor governance practices (corruption/nepotism/political patronage) meant that job opportunities only reached those with contacts/connections to local/national power structures. Established social structures and exclusion also mean that there is very high risk of only 'connected' groups gaining from Project benefits, if these are not managed through a transparent and effective decision-making process. If local residents are excluded from Project benefits due to existing power structures, the Project runs high risk of both increasing vulnerability and social exclusion and of creating resentment against the MOW/SIF, and by extension the Government of Belize although performed through contracted agents. Likewise, women and youth may also be excluded from Project benefits unless special attention is directed to them.

CHAPTER 7: ASSESSMENT OF ALTERNATIVES

7.1 Introduction

This section of the ESIA presents the assessment of alternatives considered related to proposed rehabilitation of Miles 8.5 to Miles 24.5 of the Philip Goldson Highway and the potential environmental and social impacts associated with the proposed road rehabilitation activities. The assessment of Alternatives deals with alternatives to some of the most critical issues relevant to the proposed highway rehabilitation and is closely related to the overall environmental and social impacts currently being assessed.

7.2 Assessment of Alternatives

As part of the EIA requirement, there is the need to assess alternatives to a proposed development and its associated activities. In considering the implementation of a proposed conceptual plan, there is often a consideration of the various alternatives that a project proponent would have to consider prior to a decision to move forward with the plan. There are usually two or more important alternatives for each major proposed activity to be considered.

The evaluation of alternatives may encompass a wide range of economic, social, and environmental considerations associated with the various available options. This section focuses on the evaluation of the major alternatives to the proposed rehabilitation of Mile 8.5 to 24.5 of the Philip Goldson Highway, inclusive of the 'No Action Alternative'. The discussions focus on the options that are most practical for the proposed Study Area.

Preliminary baseline information indicates that the major issues associated with the rehabilitation of this section of the Philip Goldson Highway are those primarily associated with the need to:

- Rehabilitate the entire length of the road section based on design speeds considerations,
- Enhance the highway's resilience to the frequent severe storm events and climate change effects;
- Improve existing drainage conditions impacting this section of the highway;
- Rehabilitate or replace existing culverts and drainage system inclusive of the existing Mexico Creek Bridge if needed;

- Provide roadway widening in certain areas in consideration of present and projected traffic use;
- Consideration of roundabouts or other measures to improve access to this section of the Philip Goldson Highway at points of intersection;
- Pavement reconstruction for projected traffic 20 years from now or a projected life of 20 years; and
- Improve road safety through pedestrian and bicycle facilities in urban areas, improved road lighting through the villages and adequate signing and marking of the roadway;

Baseline information was specifically obtained to assist in the selection of alternatives being considered to address some of the most critical issues identified earlier, while planning for projected climate change impacts and disaster risk management. This informed the assessment of alternatives discussed below and the final selection of the recommended options.

7.3 Road Design Alternatives Considerations

The primary alternatives considered included the examination of a minimum of three main alternatives for the rehabilitation of the Philip Goldson Highway, viz. the "no action' alternative and two other potential technical options for the following critical issues identified:

a) Road Design Speed in consideration of road safety issues and the passage of the highway though rural and urban Area;
b) Vulnerability of road section to flooding from heavy rainfall, backflow of Belize River and storm- surge and projected Climate Chang Impacts and existing poor drainage conditions;
c) Road Surfacing consideration to improve road resiliency in addressing present and projected climatic conditions.
d) Need for improved Highway access at points of intersections along this section of highway

This section provides a discussion of the implications of these options in terms of their impacts to the environment and ecosystem of the area, climate adaptation and risk reduction and the need to improve road safety issues with the current roadway. This section also provides recommendations on the consideration of what recommendations for road rehabilitation could be best considered as short, medium, and long-term interventions based on a prioritization of all necessary road rehabilitation interventions (road section, bridge/ drainage system) considering environmental, social, technical, and economic factors.

In the analysis of the various alternatives, the option with the highest cost benefit, the most technically feasible and with the least residual environmental and social impacts is usually identified as the preferred option.

7.3.1 The 'No Action Alternative'

The **'No Action Alternative'** although discussed and required to be considered, often represents an option in these types of projects that is not always the least impacting and in the best interest of the general public, or proponent, from an environmental, economic and social point of view. In these instances, both the proponent (MOW) and regulatory agency need to consider the economic and social opportunities a project of this nature presents in addressing outstanding issues and the future development of the area. The no action alternative only becomes a viable option where it is determined that a project's environmental and social impacts would far outweigh any net economic and social benefit, which is not the case in this instance.

Although in many cases the 'no action alternative' would often result in the least negative environmental impacts, this is not always the case as in this instance. In addition, this option also has the potential to be the most economically expensive option due to the potential opportunity cost, which would be lost in addressing existing road safety conditions and the required improvements needed in maintaining this important road artery safe and operational during national emergencies. This section is important in maintaining the links open to the only international airport and the main military bases in the country.

7.3.2 Base Conditions of the Highway and Impacts

The PGH is a two-lane, 92.1-mile highway, originally built in the early 1980s to upgrade the old Northern Highway, and was resealed approximately 13 years ago. Since then, the roadway´s pavement has deteriorated significantly, in particular between Ladyville (mile 8.5) and Gardenia Village (mile 24.5), due to: (i) insufficient/poor drainage; (ii) the sharp increase in truck and bus traffic transporting workers and commerce in and out of Belize City, and to a lesser extent, the agriculture and tourism sectors; and (iii) limited maintenance.

The condition of the road surface ranges from fair to poor over different sections of the road. The pavement surface with poor condition is located between the Lake Garden Community junction at mile 11.25 and Los Lagos Community at mile 13.5. The remaining sections have a running surface that is in fair conditions.

There is also the urgent need to improve highway access from streets that intersect with the highway in the Ladyville and Lords Bank area to avoid traffic accidents and to prevent bottleneck conditions experienced at these junctions during peak traffic periods in the morning and evening hours. The pavement's conditions together with the absence of paved shoulders, unsafe road alignments, lack of pedestrian facilities in urban areas, and limited marking and signage have contributed to relative high incidence of road fatalities.

In addition, flooding and a failing pavement greatly restrict mobility along the road and make evident infrastructure vulnerabilities during extreme weather events. This is significant as the highway is a primary evacuation route for coastal areas and the Cayes including Belize City. Of particular concern is the stretch from the Airport Junction (mile 9.5), susceptible to flooding, located in Ladyville. Another stretch is the section near Mexico Creek Bridge which has been submerged with about 6 inches of water for a half mile distance at least twice in the last ten years and frequently has water straining the superstructure at Mexico Creek Bridge (mile 20.5). Other low lying areas located near the Double Run road access and the Burrell Boom Junction have also been identified as potential areas requiring attention.

The team also identified several critical areas of safety concern that need to be addressed. These include the present bottleneck conditions at the Vista Del Mar Junction, and three sharp curves located in miles 16, 17 and 18 respectively.

The current baseline conditions indicate why the **'No Action Alternative'** is not a practical option and why it should be used primarily as a baseline mark from which to assess the impacts of the proposed highway rehabilitation activities. The identification of options is therefore centred on the assessment of two or more other potential technical options. It also looks at the alternatives to mitigate against critical issues of concerns associated with the proposed road rehabilitation activities. A choice was made on the option that was most economically viable while at the same time resulting in the least negative environmental and social impacts or external costs.

7.3.3 Assessment of Design Speeds Alternatives

The remaining two technical options with respect to speed design include the following:

i) Option I: an AASHTO standards two-lane undivided highway with paved shoulders accommodating a design speed of 100 km per hour in rural settings and 40 km per hour two lane highway in urban areas between Lords Bank and Ladyville to be considered as the Technical and Feasibility **TOR Design Speed option**;

ii) an AASHTO standards for a two-lane undivided highway with paved shoulders accommodating a design speed of 100 km per hour in most rural settings but which remains within the existing highway ROW and considers the minor smoothing out of curves and the use of speed reducing measures to address road safety issues in identified sharp curves and a 40 km per hour four-lane highway in urban areas between Lords Bank and Ladyville as a possible **Variable Design Speed option.**

7.3.3.1 Alternative I: Technical Feasibility Team TOR Design Speed Option

This option would allow for implementing AASHTO design speed standards associated with an improved major highway alignment addressing long term planning and future projected use. Maintaining a 100km per hour throughout the rural areas from Lords Bank to the ends of the road section at miles 24.5 **would require significant horizontal alignment and accompanying significant land acquisition cost.**

The social impacts from the required horizontal alignments would be relatively high and primarily associated with shifting property values, loss of highway services in areas of realignment, temporary disruption, and disturbances caused by road construction activities. The social implications associated with the acquisition of private properties and the loss of access to highway services by existing homes along areas of alignments in would be relatively high. In addition, the construction of these new sections of road alignments would require much larger volumes of sub-base and base material with their increase accompanying environmental impacts. Hence, the economic cost of the construction of these new alignment sections and those associated with mitigating both their social and environmental impacts would be relatively high.

In addition, the two-lane highway in the urban area between Lords Bank and Ladyville would not adequately address the traffic congestion that occurs in this area during peak traffic hours in the morning and evening from daily commuters.

7.3.3.2 Alterative II: Variable Design Speed Option based on Conceptual Design Alternative

This option is almost similar to option I only that it confines all road alignments and other road rehabilitation activities to the existing highway right of way and would only address issues of encroachment within the existing ROW to accommodate the proposed road rehabilitation activities. In this option a design speed of 100 Km per hour is maintained for most rural areas with some reduced speed when passing through communities or to address road safety issues at a few curves located at miles 16, 17 and 18.

In section 2a reduced speed zones through settlement areas having design speeds of 60 km/h (35 mph) is recommended; this section of the highway is recommended as an undivided 2 lane highway including 2 bicycle fully paved shoulders. For the Section between Sandhill to Mile 24.5, a design speed of 100Km per hour is recommended with a 2-lane undivided highway having 2.5 m wide shoulders of which 1 meter would be paved.

This variability in design speeds takes into consideration the passage of the highway though rural communities and an urban setting, which exists in the Lords Bank and Ladyville area with speed limits of 40 km per hour, making provisions to address community needs, projected traffic use, and traffic safety issues.

The alignment through the Sand Hill area is recommended to introduce minor curve flattening to achieve consistent design speeds and improved visibility. The impacts of this alignment on the areas ecosystem would be minimal with the need to pay greater attention to maintaining proper and adequate road drainage and preventing the flooding of adjacent properties due to road realignment. The potential impacts to the environment and resources of the area are for the most part readily mitigated, while offering an opportunity for significant benefits to be derived from the implementation of the proposed activities.

This option would reduce significantly the social implications associated with the proposed highway rehabilitation project and the cost associated with land acquisition and would also have the least environmental impacts. As such, this would be the least costly and with the least negative environmental and social impacts of all three technical options.

7.3.3.4 Qualitative Summary of Speed Design Alternatives

Table 7.1 provides a summary of a rapid qualitative comparative assessment of the options considered with respect to highway design speeds considered.

Table 7.1: Proposed Alternatives for Highway Design Speed.			
Alternatives	**Parameters to be Considered:**		
	Environmental	**Social**	**Economic**
1. Design Alternative I: TOR Design Speed Option	Significant impacts associated with material supply for additional sub-base; Impacts to ecosystem from new alignments are minimal; would require special attention to drainage in new areas while allowing for improvement in present conditions.	Significant impact associated with land acquisition and loss of highway frontage and services by roadside homes in areas of alignments. Allows for improvement to social amenities such as bicycle lanes, lighting and bus stop; Reduced Risk to motorist from road alignments;	Significant and high cost of land acquisition and increased capital cost associated with construction of these new highway sections.

2. Design Alternative II: Variable Design Speed Option	Impacts to environment from reduced horizontal alignment and associated material supply is reduced significantly. Allows for improvement to existing drainage conditions. Impact to ecosystem is minimal.	Cost of land acquisition is significantly minimized to areas of proposed roundabouts; Risk to motorists is also reduced; Allows for improvement to social amenities such as bicycle lanes, sidewalks, lighting and bus stop; The potential negative social implications are significantly reduced while still allowing for improvement to social amenities such as bicycle lanes, lighting, and bus stop; Risks to motorist is also reduced.	Costs of land acquisition is acceptable and justifiable as a long-term investment cost. This option would have the lowest Economic cost.
3. No action alternative.	Least environmental impacts.	High social cost due to continued lack of social amenities and possible loss of life associated with current road safety issues	Very high long-term economic cost.

Both options would allow for improvement to current road drainage system and protection of road slopes to enhance resilience to the projected more frequent severe storm events and climate change effects. They would allow for highway widening in required areas and improve road safety through pedestrian and bicycle facilities in urban and rural community areas, improved road lighting through the villages and adequate signing and marking of the roadway.

While both options would result in the benefits discussed above it is recommended that the rehabilitation consider upgrading the road in accordance with the second technical option.

7.3.4 Alternative for Points of Intersections

Along this sixteen-mile section of highway, there are several important points of intersection that would need to be considered in the highway rehabilitation to allow for safe access and egress to highway. Some of these points of intersection have been identified as potential bottlenecks and high-risk sites for accidents. Travelling from south to north, these sites include the following:

- Vista Del Mar Junction (Javier Berbey Garcia Sr. Boulevard)*
- Philip Goldson International Airport Road Junction**#
- Scissors Tail Street Junction
- Pigeon Street Junction
- Poinsettia Street Junction**
- Old Airport Road Junction (Belikin Road)*

- Marage Road*
- Lords Bank Road**#
- Old Northern Highway Junction leading to Lake Gardens
- Los Lagos Access Road
- Burrell Boom Junction**#
- Maxboro Road Junction
- Double Run Junction
- Old Northern Highway Junction (Maskall Road)*

** Major Intersection with heavy traffic; * Intersection with moderate traffic use; # Proposed roundabouts.

There are several other smaller accesses not mentioned. The project is recommending that three major intersections have roundabouts, matching recent major intersections constructed on the Western Highway. These roundabouts will provide continuous flow (which will avoid illegal movements to avoid queues) and accomplish speed control for passage of pedestrians.
Minor side roads are recommended to consider either a left turn lane or a right-side bypass lane. The preference is for the right-side bypass lane to avoid collisions as drivers locally may not respect the left turn lane markings (or they may not be maintained). The right-side bypass lane will operate even if lane markings are not maintained.

Also recommended were pavement markings: centreline striping (to define passing opportunities/no passing zones; right lane edge striping on curves; and right lane striping where full or partial pavement is used on shoulders or there are bike lanes.

Tables 7.2a- 7.2f provide the consideration of Alternatives for five major intersections.

Table 7.2a: 1-Vista Del Mar (Javier Berbey Garcia Sr. Boulevard) Junction.

Alternatives	**Parameters to be Considered**		
	Environmental	**Social**	**Economic**
Alternative I: Roundabout	Negligible: will require small amounts of vegetation clearance and subsequent land	Moderately High impact associated with land acquisition for roundabout Allows for improvement to social amenities lighting and bus stop; Improved Road Safety and Reduced Risk to motorist and pedestrians. This improvement should be accompanied to the paving of Javier Berbey	Would require the acquisition of approximately 6070 square metres of land for highway ROW widening to allow

	filling.	Boulevard to the Junction with Perez Road to allow for use of this as major inlet and outlet of the Ladyville Area, which could also serve as a detour during road rehabilitation activities.	roundabout and placement of bus -stop. Justifiable as a long-term investment cost
Alternative II Redesign of Existing T-junction	Negligible Impacts	Similar to those associated with roundabout only that acquisition of land is reduced to those associated with bus stops. Improved access, which would need to be regulated by a traffic light or officer. Risk to motorists and pedestrians is also reduced;	Would require the acquisition of approximately 588 square meters for bus stop and waiting bay.
Alternative III No action alternative.	Least environmental impacts.	The present structure does not allow the smooth flow of traffic; concerns raised with respect to busses parking on the carriageway to embark and disembark passengers creating traffic backlog and traffic hazard. Bar on the side of the highway near Belize River bank is a safety issue.	Very high long-term economic cost due to loss of opportunity costs.

Alternative II is recommended as the preferred options due to space constraints.

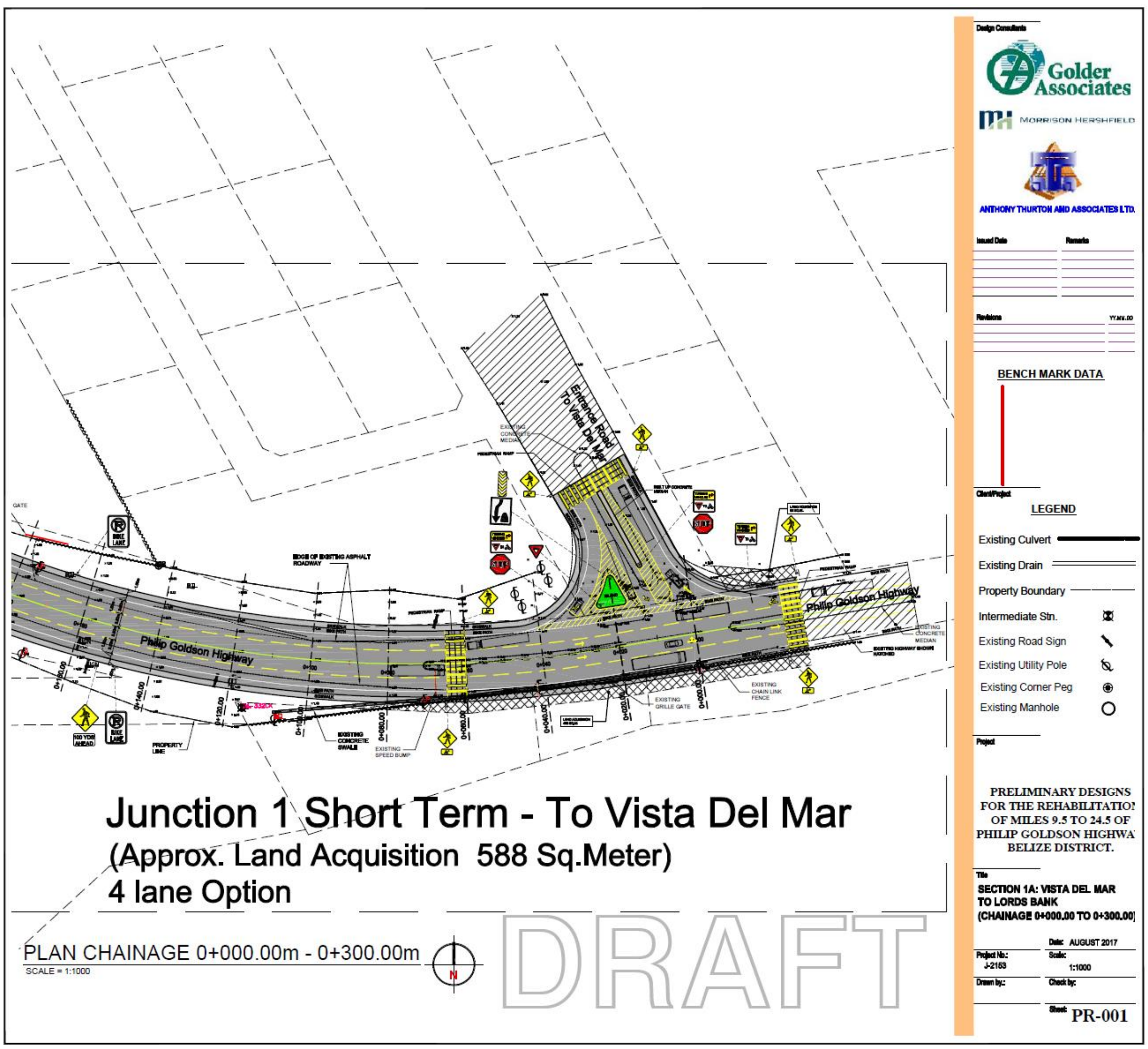


Figure 7.1: Alternative II proposed Vista Del Mar T Junction.

Table 7.2b: 2-International Airport Junction.			
Alternatives	**Parameters to be Considered**		
	Environmental	**Social**	**Economic**
Alternative I: Roundabout	Negligible Impacts	May require some little land acquisition for roundabout. This will allow for optimal use of available land while allowing for improvement to social amenities (sidewalks, lighting and bus stops); Needed for Improved Road Safety and Reduced Risk to motorist and pedestrians in consideration of the Link Road connecting to the GPH and the future increase in traffic at this point.	Would require the acquisition 905 square meters of land to allow roundabout and placement of bus -stop. Justifiable as a long-term investment cost
Alternative II Redesign of Existing T-junction	Negligible Impacts	Similar to those associated with roundabout only that acquisition of land is avoided. This Improved access will still need to be regulated by a traffic light or officer. Risk to motorists and pedestrians is also reduced;	Cost of capital investment is low but its operational cost would be long-term.
Alternative III. No action alternative.	Least environmental impacts.	The present structure does not allow the smooth flow of traffic and may increase its risk for accidents with the expected increase in traffic when the link road with the GPH is implemented. Concerns have been expressed on the current layout of dividers and their risk to motorists.	Very high long-term economic cost due to loss of opportunity costs.

Alternative I is the recommended as the preferred option.

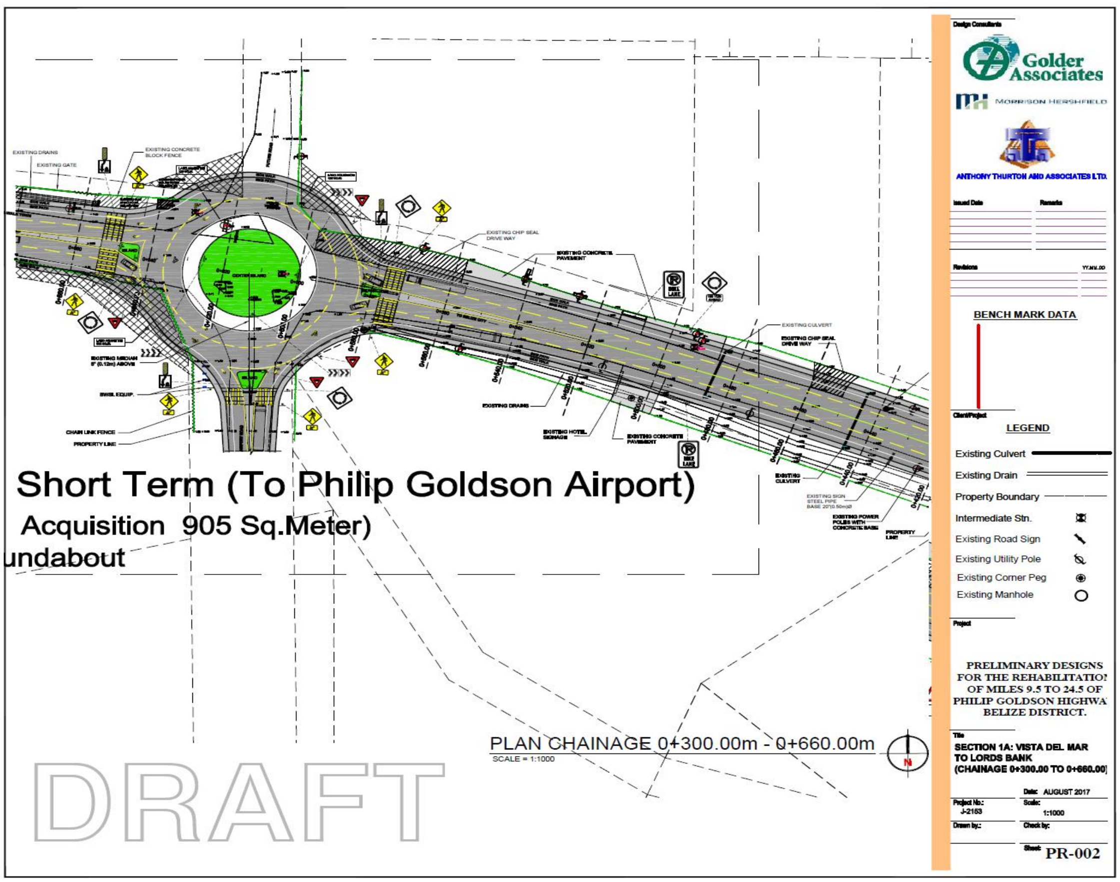


Figure 7.2: Alternative I: Proposed Philip Goldson Airport Roundabout.

Table 7.2c: 3-Poinsettia Street Junction.			
Alternatives	**Parameters to be Considered**		
	Environmental	**Social**	**Economic**
Alternative I: Roundabout and realignment of Old Belikin Road	Moderate Impacts Negative impacts associated with proposed realignment of the Old Airport Road (Belikin Road) and filling of low lying area and its negative impact on localized drainage	Will require substantial acquisition of land for alignment of old airport road and limited amounts for roundabout. This allowing for side roads (Poinsettia St, and Belikin Road) to safely access highway and for improvement to social amenities lighting, sidewalks, bicycle lanes and bus stop; Needed for Improved Road Safety and Reduced Risk to motorist and pedestrians in particular during peak traffic hours (7:30 am) in the morning and evening (5:30 pm).	Would require the acquisition of substantial amount of land. Allow its economic impact could be justified as a long-term planning cost.
Alternative II Roundabout without any realignment of Old Airport Road	Impacts are low mainly associated with improvements in drainage.	It social impact associated with the potential impacts of land acquisition on the west side is acceptable and would impact one landowner.	Cost of land acquisition is significantly lower than option I and may allow for earlier implementation than option I.
Alternative III Placement of a T- junction	Negligible Impacts	Acquisition of land is avoided. This Improved access will still need to be regulated by a traffic light or officer. Risk to motorists and pedestrians is also reduced;	Cost of capital investment is low but its operational cost would be long-term.
Alternative IV. No action alternative.	Least environmental impacts.	The present condition is not conducive to road safety. There is a true need for the improvement of social amenities at this very busy and important Ladyville junction. The junction presently presents a high level of risk for traffic accidents	Very high long-term economic and social cost due to loss of opportunity costs.

Alternative III is the preferred option.

Table 7.2.d: 4-Marage Road Junction.			
Alternatives	**Parameters to be Considered**		
	Environmental	**Social**	**Economic**
Alternative I: Roundabout	Negligible Impacts	May require some land acquisition for roundabout. This will allow for optimal use of available land while allowing for improvement to social amenities lighting, bicycle lanes sidewalks, and bus stop; Needed for Improved Road Safety and Reduced Risk to motorist and pedestrians in consideration of the Link Road connecting to the GPH and the future increase in traffic at this point.	Would require the acquisition of some land presently mot justified by tow volume of traffic. However, may be justifiable as a long-term investment cost
Alternative II Redesign of Existing T-junction	Negligible Impacts	Similar to those associated with roundabout only that acquisition of land is avoided. This improved access will need to be regulated by a traffic light or officer and should be accompanied by alternating bus stops on both sides of the highway. Risk to motorists and	Cost of capital investment is low but its operational cost would be long-term. Allow for easy short-term implementation

		pedestrians is also reduced;	
Alternative III. No action alternative.	Least environmental impacts.	The junction's social amenities need to be improved. In addition, the area will require the construction of longitudinal drains eastwards to low lands near Mackintosh Ponds, then out to sea. The proposed longitudinal drain on opposite side of PGH will outflow to the adjacent public low lands or rush ponds.	Very high long-term economic cost due to loss of opportunity costs needed to improve social amenities and drainage in the area.

Alternative II is the preferred option.

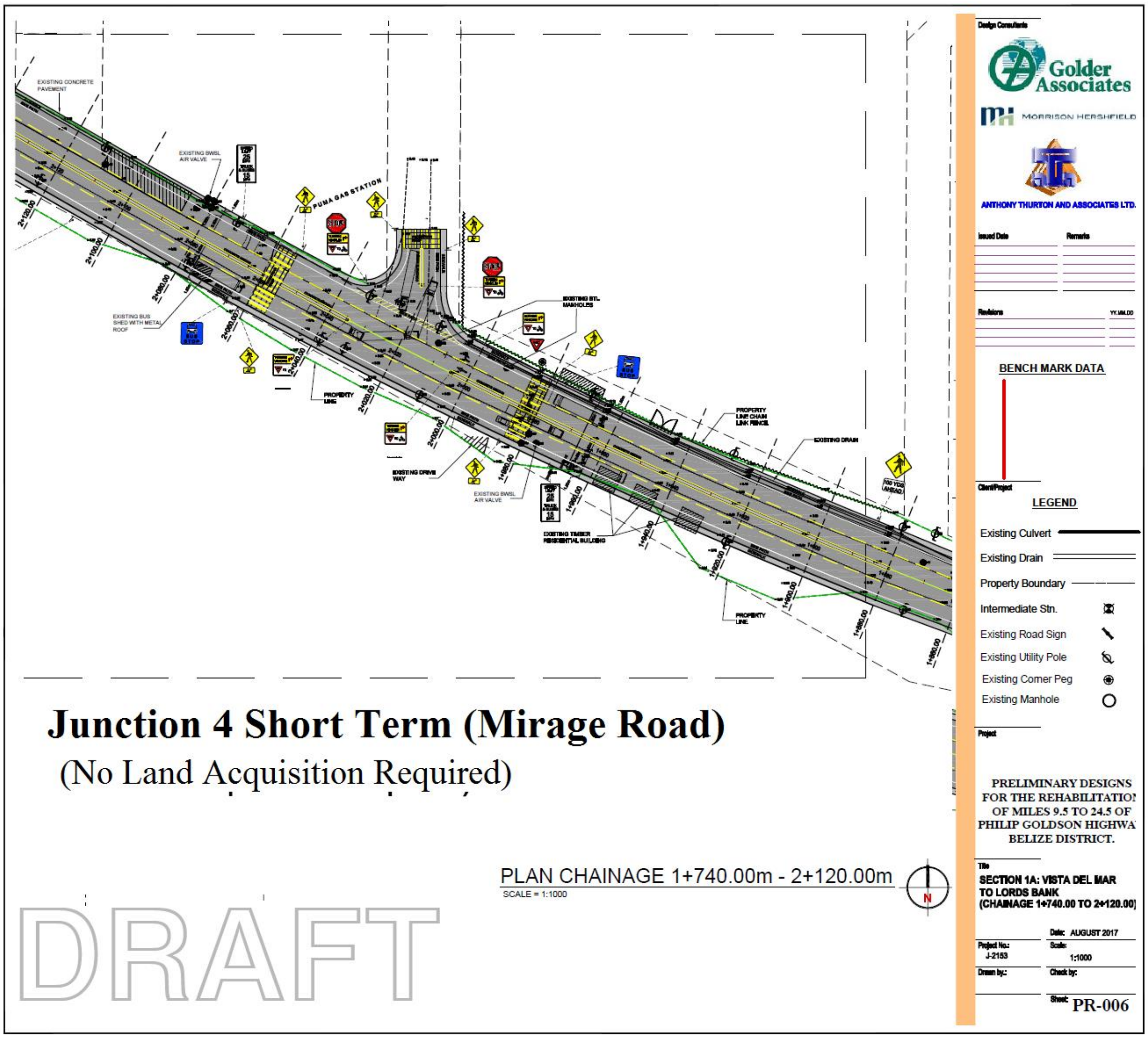


Figure 7.3: Alternative II: Proposed Marage Junction.

Table 7.2 e: 5-Lords Bank Road Junction.			
Alternatives	**Parameters to be Considered**		
	Environmental	**Social**	**Economic**
Alternative I: Roundabout	Negligible Impacts	Will require some land acquisition for roundabout. This will allow for optimal use of available land while allowing for improvement to social amenities (sidewalks, lighting and bus stops); Needed for Improved Road Safety and Reduced Risk to motorist and pedestrians in consideration of the high traffic at this junction. Gas Station at this junction is a constraint, may need to limit entrance and exit to gas station with respect to proposed roundabout.	Would require the acquisition of land to allow roundabout and placement of bus -stop. Justifiable as a long-term investment cost To alleviate the flooding in the Lord's Bank community area, it is recommended that Longitudinal drains are constructed/connected from the PGH drain, along the length of the Lord's Bank road to the Belize River. Additional cost to road improving drainage in the area should be given high priority consideration.
Alternative II design of a new T-junction	Negligible Impacts	Similar to those associated with roundabout only that acquisition of land is avoided. This Improved access will still need to be regulated by a traffic light or officer. Risk to motorists and pedestrians is also reduced;	Cost of capital investment is low but its operational cost would be long-term.
Alternative III. No action alternative.	Least environmental impacts.	The present access is unacceptable due to high risk for traffic accident. The area is in need of improved social amenities. To alleviate the flooding in the Lord's Bank community area, it is recommended that longitudinal drains be constructed/connected from the PGH drain, along the length of the Lord's Bank road to a sedimentation pond overflowing into riparian vegetation near the Belize River	Very high long-term economic cost due to loss of opportunity costs.

Alternative 1 is the recommended option.

Table 7.2 f: 6-Burrell Boom Road Junction.			
Alternatives	**Parameters to be Considered**		
	Environmental	**Social**	**Economic**
Alternative I: Roundabout	Negligible Impacts	Will require some land acquisition for roundabout. This will allow for optimal use of available land while allowing improvement to be able to safely access the PGH. Land acquisition may become necessary due to angle at which The Burrell Boom Highway meets the PGH. Round about is needed for road safety to reduced risk to motorist and pedestrians in consideration of the high traffic at this junction.	Would require the acquisition of land to allow roundabout and placement of bus stops. Land may need to be acquired to allow for realignment of the Burrell Boom Road to improve its angle of incidence with PGH. Justifiable as a long-term investment cost. .
Alternative II Redesign of Existing T-junction	Negligible Impacts	Similar to those associated with roundabout only that acquisition of land is avoided. This Improved access will still need to be regulated by a traffic light or officer. Risk to motorists and pedestrians is also reduced;	Cost of capital investment is low but its operational cost would be long-term.
Alternative III. No action alternative.	Least environmental impacts.	The present access is unacceptable due to high risk for traffic accident. Presently large tractor-trailers are forced to ride the divider because they are unable to make the turn.	Very high long-term economic cost due to loss of opportunity costs.

Alternative 1 is the recommended option.

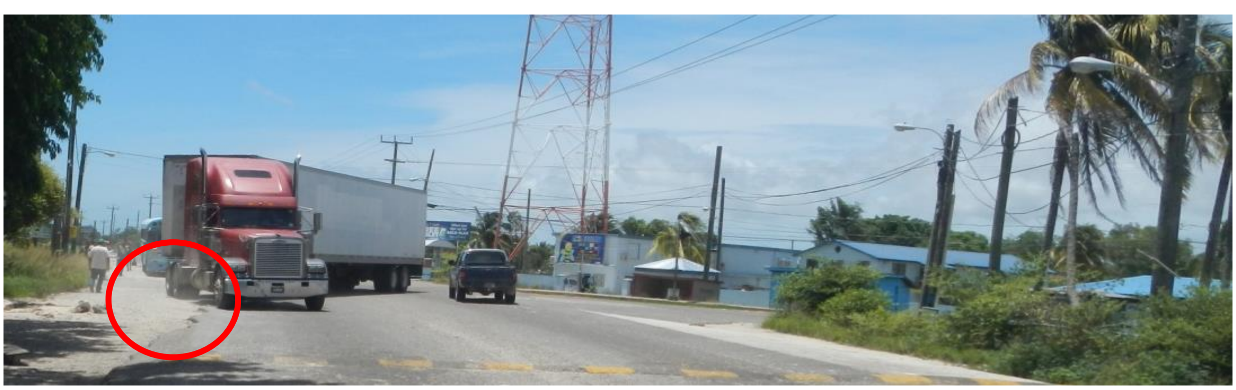


Figure 7.4: Tractor Trailer manoeuvring the Burrell Boom Junction tracking off pavement.

7.3.5 Other Design Features

Sidewalks

The sidewalks in rural areas are effective in reducing pedestrian collisions. Sidewalks along the road that passes through the villages are justified at points of development that generate pedestrian concentrations, such as residential areas, schools, parks, community centres and businesses. Shoulders may obviate the need for sidewalks if they are of a type that encourages pedestrian use in all weather conditions.

Sidewalk widths in populated areas are to have a minimum width of 1.2m. As a general practice, sidewalks should be constructed along any road not provided with shoulders, even though pedestrian traffic may be light. Sidewalks should have all-weather surfaces to serve their intended use. Without them, pedestrians often choose to use the travelled way. Wherever there are pedestrian concentrations through villages or populated areas, appropriate traffic-control devices should be used, together with appropriate walkways constructed within the right-of-way.

Bus Stops and Lay-bys

The rehabilitation of the road will be impacted by an increase in traffic particularly an increase in bus travel since it is an increasingly important mode of mass transportation. Bus lay-bys serve to remove the bus from the travelled way. The location and design of lay-bys and bus shed should provide ready access in the safest and most efficient manner practical in the populated areas or known tourist destinations.

To be fully effective, bus turnouts should incorporate (1) a deceleration lane or taper to permit easy entrance to the loading area, (2) a standing space long enough to accommodate the maximum number of vehicles expected at one time with a minimum of one, and (3) a merging lane to enable easy re-entry into the travelled way. The deceleration lane should be tapered at an angle that is flat enough to encourage the bus operator to pull completely clear of the through lane before stopping. A taper of about 5:1, longitudinal to transverse, is a desirable minimum. The loading area should provide about 15 m of length for each bus. The width should be at least 3.0 m and preferably 3.6 m. The merging or re-entry taper may be somewhat more abrupt than the deceleration taper but, preferably, should not be sharper than 4:1.

Road Signs and Markings

Traffic signs are to be designed to provide enhanced safety to motorists and other users. The signs are to be used to warn, guide, inform, and regulate the road users. The expected increase traffic resulting from the projected economic growth of the study area and of its population centres will require that these be of international standards.

The road markings to be applied on the paved road surface will serve to regulate and confine the traffic flow and indicate the proposed bicycle lanes in the urban areas. The type of road markings to be applied will be determined by examining visibility criteria for the design speed for both the vertical and horizontal alignments travelling in both directions.

7.3.6 Belize River Flood Alleviation Considerations

The following assessment of alternatives is based on Golder updated flood mitigation options for the PGH. The assessment indicated that the dredging of the Haulover Creek as a measure for flood alleviation on the PGH, would have little impact to reduce Belize River water levels. This Option was therefore not considered in subsequent analysis and deliberations.

In addition, preliminary assessment of the proposed 12.5 km canal between Mexico Creek and the coast indicated that it would contribute to significant reduction in riverine flooding for the entire river stretch downstream of Mexico Creek. However, the cost and environmental impacts would both be prohibitively high. After further deliberations with key project stakeholders, this option was abandoned.

Proposed flood adaptation and mitigation options

Option 0: ***Raise the Road to 25-year flood level***

Raising the PGH crest to an elevation above the calculated Belize River flood levels in consideration of the proposed criteria for the road design. This is the base option.

Unit costs are being used to support the cost – benefit analysis.

Costs: Additional road raising: $10,000 USD/0.10 m of additional road crest raising for 100 m road section. At this rate, the cost of raising the crest of 1 km of the PGH 1 m in elevation is 1.0 M USD.

This Option would require that approximately 1,700 road lengths be raised by an average of 0.9 m, which includes 0.5 m freeboard between the proposed road crest and the calculated flood water level. Estimated cost is approximately $2.7 M USD.

Option 1: ***Large Vista del Mar Channel between the Belize River and Vista del Mar marina***

Excavate a channel between the Belize River and Vista del Mar marina roughly following the alignment of existing Vista del Mar drainage channel.

Excavate a 30-m wide (at the base), 3H:1V side slopes, 6 m deep (at Belize River) channel, approximately 950 m long channel between the Belize River and the Vista del Mar marina is projected to decrease flood water levels along PGH up to 0.4 m.

Material removal: Channel excavation volume is estimated at about 275,000 m^3 of soil.

Would require:

- A 54-m long channel crossing under the PGH
- A 6 high, 54 m wide control gate across channel close to the PGH bridge.

Costs: Total channel construction costs could exceed 6.1 M USD. Cost for concrete liner, maintenance (operation of control gate, cleaning of channel), land acquisition, potential environmental mitigation and monitoring costs, and coastal dredging cost not considered, and would raise the total cost.

Option 2: ***Vista del Mar Channel between the Belize River and the Vista del Mar marina***

Excavate a channel between the Belize River and Vista del Mar marina roughly following the alignment of existing Vista del Mar drainage channel.

Excavate a 5-m wide (at the base), 3H:1V side slopes, 2 m deep (at Belize River) channel, approximately 950 m long between the Belize River and the Vista del Mar. marina. It is projected that this would decrease the water level along the PGH by only 0.06 m.

Material removal: Channel excavation volume estimated to be approximately 21,000 m^3 of soil.

Channel construction would also require construction of:

- A 13 m channel crossing under the PGH
- A 2 m high, 13 m wide stop logs control gate across the channel near the PGH bridge.
- A second 13 m long bridge at the Vista del Mar road.

Costs: The total channel construction costs could exceed $0.8 M USD. Here again, the cost for concrete liner, maintenance (operation of control gate, cleaning of channel), land acquisition, potential environmental mitigation and monitoring costs, and coastal dredging cost not considered, and would also raise the total cost.

Option 3: Connecting the Belize River to Two Existing Clover Leaf Canals South of the Vista del Mar Road Junction

Excavate channel connecting the Belize River with two existing drainage canals called the Clover Leaf canals, which extend between the coast and close to the PGH about 800 m south of Vista del Mar road junction. Channels need to be extended about 100 m to connect to the Belize River. The extension will be via a 24.4 m wide channel, 1H:1V side slope, 4.5 m deep to match the combined dimensions of the two exiting Clover Leaf canals. Additional excavation will be required at canal outlets on the coast. This measure would decrease the flood water levels along the PGH by 0.25 m.

Material removal: The excavation volume for extending the canals was estimated to be 13,000 m^3. This does not include some dredging at the canal's confluence at the coast.

The extended canal construction would also require the construction of:

- Two 12 m long canal crossings structures (box culverts) under the PGH.
- A 4.6 m high, 24 m wide stop logs control gate (or multiple smaller gates) across canal close to the PGH crossing.
- A concrete lining of the existing canals to control vegetation growth.

Costs: A total construction cost is estimated at approximately $3.4 M USD, provided that the excavation is done by a private developer in the area. The cost for concrete liner, maintenance (operation of control gate, cleaning of channel), potential environmental mitigation and monitoring costs, and coastal dredging cost has not been considered, and would raise the total cost.

Option 4: Enlarge the Existing Clover Leaf Canals and connect them to the Belize River

Enlarge the two existing Clover Leaf canals to a total width of 30 m (15 m each), and change to vertical slopes by installing sheet piles or similar structural measures. Deepen canals to achieve a depth of about 4.5 to 5.0 m from Belize River to the coast.

This measure would decrease the flood water levels along the PGH by up to 0.38 m.

Material removal: Excavation volume for canals' extension and canals enlargement estimated to be 14,00 m^3. This volume does not include some dredging at the canals' confluence near the coast. Additionally, the canal construction would require the construction of:

- A 30 m long canal crossing (box culverts) under the PGH.
- A 6 m high, 30 m wide stop logs control gate (or multiple narrower gates) across the canals close to the PGH crossing.
- Concrete lining of the bottom of the existing canals to control vegetation growth. Also, sheet pile lining of the canals' side to support the vertical sides.

Costs: The total construction costs were estimated at $3.8 M USD provided the excavation is done by a local developer. The cost for concrete liner, maintenance (operation of control gate, cleaning of channel), potential environmental mitigation and monitoring costs, and coastal dredging cost not considered, and would raise the total cost.

According to Golder's engineering group, no land acquisition costs are foreseen for Options 3 and 4.

Costs

Unit costs are recommended for use to support the cost – benefit analysis.

Additional road raising works:

$10,000 USD/0.10 m of additional road crest raising for 100 m road section. At this rate, the cost of raising the crest of 1 km of the PGH 1 m in elevation is USD 1.0 M.

Channel excavation works:

$15 USD/$m^3$ of excavated soil.

Table 7.3 provides a rapid assessment of the flood mitigation measures contained in the Golder Associate Ltd. Conceptual Design Report.

Table 7.3: Summary Assessment of Flood Mitigation.

Option	Approximate Excavated Volume of Soil (m^3)	Flood level reduction for segments of PGH
0 - *Raise the Road to 25-year flood level*	Minimal	Resilience for 1:25 year flood event, specifically Ladyville area.
1 - *Large Vista del Mar Channel between the Belize River and Vista del Mar marina*	275,000	0.4 m in Vista del Mar channel diversion to 0 m approx. 7.5 km west
2 - *Vista del Mar Channel between the Belize River and the Vista del Mar marina*	21,000	0.06 m at Vista del mar channel diversion point to 0 m approx. 2.4 km to the west
3 - *Connecting the Belize River to Two Existing Clover Leaf Canals south of the Vista del Mar Road Junction*	13,000	0.25 m at Mile 8.5 PGH to 0 m approx. 6.5 km to the west
4 - *Enlarging the Existing Clover Leaf Canals and Connect them to the Belize River*	140,000	0.38 m at Mile 8.5 PGH to 0 m approx. 6.5 km to the west

Brief Remarks

For mitigation measures other than raising the Ladyville section of the PGH, construction costs of measures were estimated to be higher than the cost of raising the road crest by a height equivalent with the impact of the mitigation measure. Other considerations were:

- Flood mitigation measure associated costs include: regular cleaning of diversion channel; maintenance of flood control gates, and channel lining.

- Environmental impacts: environmental monitoring and potentially, compensation efforts.

- Reduction of Belize River flooding benefits not quantified include: decrease in flood risks and damages of other structures other than PGH; savings in costs related to raising the PGH beyond direct construction costs such as savings in modifications to adjacent infrastructure.

- The Option with the greatest flood level reduction for a longer stretch of road is Option 1. However, all conceptual channel options proposed for flood alleviation are designed to connect the Belize River to the coast, and involve major engineering works with significant environmental and social impacts, and high costs. The recommendation is to conduct further hydraulics and feasibility studies, and detail investigation on the impacts of these flood mitigation measures on the coastal ecosystem and wetlands. This would need further careful consideration to inform the choice of the best flood mitigation option for the Mile 8.5 to 24.5 segment of the PGH.

7.3.7 Road Surfacing Alternatives

The assessment of baseline information indicated that almost the entire length of the PGH would need to be resurfaced with the exception of approximately 0.4 miles from the Vista Del Mar Junction to the Philip Goldson International junction, which was recently resurfaced and appears to be in good condition. The evaluation for road surfacing looked at the following four alternatives: a flexible chip seal surfacing; using a semi-structural flexible hot mix asphalt road surfacing; using a rigid concrete surfacing and the no action alternative. Noise reducing pavements were also examined because of their ability to reduce noise by five or more decibel levels. In the USA these pavements or specialized asphalt mix were estimated as 25% costlier than the normal hot mix. Hence, because of their local unavailability, local application knowledge and their cost are not further examined as potential alternatives; Table 7.4 provides a qualitative assessment of the issues related to each option considered.

Table 7.4: Qualitative Assessment of Technical Alternatives for Road Surfacing.

Alternatives	**Parameters to be Considered:**		
	Environmental	**Social**	**Economic**
Alternative 1: Double Chip Seal	Design life of pavement requires resealing at 7-year intervals based on traffic projections. This option requires proper and timely maintenance to ensure its impermeability to water. Produces small amounts of contaminants to water associated with	Achieving Design life of 20 years is conditional on timely routine and periodic maintenance Relatively short period of disturbance during construction. MOW and local contractors are most familiar with this alternative; this alternative also allows for greater employment opportunities and injection of resources into the local economy (multiplier effect). More comfortable ride, greater traction, and higher visibility of pavement markings	Low capital cost ($58/m^2$), but higher maintenance cost. This option provides for low initial capital investment and with a robust maintenance program, may be the most economically viable in consideration of the projected traffic volume.

	petroleum-based products.	relative to concrete for improved road safety.	
Alternative 2: Hot mix	Moderate life cycle requiring less frequent repairs and use of materials. Produces small amounts of contaminants to water associated with petroleum-based products.	Moderate life cycle of 16-25 yrs. when correctly applied; MOW and local contractors have less experience working this alternative limiting the competitiveness of local contractors in the bidding process. Period of disturbance is equitable to that of RS 1. More comfortable ride, greater traction, and higher visibility of pavement markings relative to concrete for improved road safety.	Moderate to high capital cost averaging $85/m^{2;}$ cost which almost equates to that of concreting and at a cost of 50% more than that of RS1. The higher initial capital investment renders this option less economically feasible. Only two contractors have capacity to do Hot Mix and therefore maintenance of the Hot Mix pavement will be restricted to two entities giving rise to possible collusion or monopoly with maintenance works.
Alternative 3: Concrete	Longest life cycle requiring few repairs and use of materials. However, wear and tear on tires is significantly increased. During the operational phase, this option has the potential to adversely impact residents with pre-existing respiratory illnesses; as well as creating higher noise levels affecting the communities along the ROW.	Longest life cycle (approx. 40 yrs.) but long period of disruption to community life and road users with most uncomfortable ride. This option also offers the least road traction and least visibility of pavement marking compared to asphalt options thus increasing safety risks. The longer construction period may also exacerbate PAPs with respiratory health issues.	Highest capital cost $100/m^2$, but could be financially prohibitive for extended road sections with high social cost because of longest disturbance period. Additionally, given the greater construction period the adverse economic impact on the tourism and agricultural sectors amongst others will be more severe than the other options. This option should be limited to those sections prone to flooding.
Alternative 4: No Action	High environmental cost due to dust, erosion and siltation and frequent material supply as a result of deteriorated road conditions.	High social cost from existing bad road conditions resulting in accidents and deaths; and high vehicle maintenance and transportation costs and illicit activities due to limited enforcement activities associated with poor conditions of road	Highest maintenance cost and environmental cost due to impacts from sedimentation and to the ecosystem services of the area due to illegal activities and loss of economic opportunities due to conditions of road and accessibility to the area.

Alternative 1 is the recommended option with sections vulnerable to flooding and storm surge impacts considering concrete to make these sections more robust.

CHAPTER 8: EVALUATION OF ENVIRONMENTAL LIABILITIES

8.1 Introduction on Environmental Liabilities

Liability is the legal responsibility borne by a party for damages caused to the receptor (Environment, community, etc.) during the execution of activities related to a project or program. "Environmental Liability" is any liability, contingent or otherwise (including any liability for damages, costs of environmental remediation, fines, penalties or indemnities), directly or indirectly resulting from or based upon (a) the violation of any Environmental Law, (b) the generation, use, handling, transportation, storage, treatment or disposal of any Hazardous Materials, (c) exposure to any Hazardous Materials, (d) the release or threatened release of any Hazardous Materials into the environment, or (e) any contract, agreement or other consensual arrangement pursuant to which liability is assumed or imposed with respect to any of the foregoing (CITI Bank, 2016).

Hence, environmental liability serves as an instrument of environmental protection for the prevention of and compensation for environmental harm. It promotes the personal responsibility of the (economic) players. Properly constituted environmental liability law creates economic incentives to prevent the occurrence of harm, paving the way for the payment by the polluter of compensation for any harm that occurs.

There are several important terms associated with environmental liabilities which include the following:

- **Environmental liabilities risk assessment** (ELRA) refers to the assessment and costing of liabilities arising from incidents.
- **Incident** generally refers to a change of circumstances from the norm with actual or potential negative consequences.
- **Financial provision** refers to the putting in place of a financial instrument (such as an insurance, bond, guarantee or fund) to cover the costs of closure, restoration/aftercare or incidents

8.2 Legal Sources of Environmental Liabilities

Environmental Liabilities arise from a variety of sources. Multilateral Environmental Agreements (MEAs), national legislation and regulations, and national environmental guidelines, whether enforced by public agencies or private citizens' suits, give rise to many types of environmental liabilities. The common law (law derived from custom or judicial precedent) also gives rise to environmental liabilities. The following are general sources from which environmental liabilities may arise:

- **Compliance Obligations**: related to the laws and regulations that apply to the manufacture, use, disposal and release of chemical substances and to other activities that adversely affect the environment (these include the Environmental Protection Act, the Environmental Impact Assessment Regulations, the Pollution Regulations, the Hazardous Waste Regulations and the Effluent Limitations Regulations);
- **Remediation Obligations**: (existing and future) relating to contaminated property;
- **Fines and Penalties**: obligations to pay civil and criminal fines and penalties for statutory or criminal non-compliances;
- **Punitive Damages**: obligations to pay punitive damages for grossly negligently conduct;
- **Natural Resource**: obligations to pay for natural resource damage or destruction.

The Environmental Protection Act of Belize provides for the courts to be able to impose a variety of criminal sanctions or civil remedies for damage to the environment such as the following:

Sanctions;

- Prohibiting the offender from doing an act or repeating an offence and directing the offender to take actions to avoid harm to the environment;
- Directing the offender to post bond or to pay money into court to ensure compliance with any sentence of the court;
- Directing the offender to compensate DOE for the cost of cleanup of the environment or other remedial action;
- Additional fine where the offender acquired monetary benefits or that monetary benefits accrued to the offender; the additional fine would be an amount equal to the court's estimation of the amount of the monetary benefits;
- Compensation for loss of or damage to property or injury to a person;
- Penalty for contravening court order;

Civil Remedies:

- Injunction on the application of the Department.
- Civil cause of action or persons who have suffered loss or damage.
- Injunction by person who suffers or is about to suffer loss or damage.

Other pieces of legislation such as the National Protected Areas System also have similar provisions for compensation for damage or civil actions to remedy assessed damages.

8.3 Characterizing and Identifying Environmental Liabilities

The environmental liabilities evaluated in this section are those that are derived from the impacts identified in the Impact Assessment portion of this report. These impacts were assessed based on the social, ecological, and physical information collected during the Environmental and Social Baseline Assessment (ESBA).

As, such, the environmental liabilities that could arise as a result of the construction activities required for the rehabilitation of the PGH from miles 8.5 to 24.5 are *potential* in nature. **These *potential* environmental liabilities depend on certain activities occurring in the future for them to become operative; but they can be prevented from occurring as the Contractors/MOW/GOB have the opportunity to alter or adopt new practices to avoid or reduce adverse environmental impacts.**

For this evaluation, these *potential* environmental liabilities are confined to the impacts that put at risk the route and its users; and impacts that put at risk the areas, ecosystems and communities near the right-of-ways; accesses and ancillary facilities during construction of the PGH and the impacts of natural hazards on the successful realization of the road restoration and operation. In other words, the environmental liabilities assessed in this section are those that arise from the assessed impacts as a result of how the road is constructed and which affect third parties who use the road, and those that arise from the assessed impacts on third parties as a result of the existence and use of the road; and are liabilities for which someone may be held legally responsible for.

The environmental liabilities evaluated are therefore classified as: Geological/Earthworks Liabilities, Hydrological/Water Pollution Liabilities, Air Pollution Liabilities, Noise Pollution Liabilities, Vibration Liabilities, Construction Related Man-Made Hazards Liabilities, Natural

Resources and Environmental Services Liabilities, Cultural Heritage Liabilities, Injury and Accidental Health Damage Liabilities, Involuntary Displacement Liabilities, and Livelihoods Destruction Liabilities.

8.3.1 Geological/Earthworks Liabilities

The geological risks within the study area are minimal and subject to very site-specific localities and do not give rise to any actionable environmental liability. These risks are to the road structure itself in that in certain areas of the road, there is the possibility of subsidence and differential settling caused by the sands in the marsh settling with high organic content underlain by the impermeable clays that create a scenario of a state of semi-permanent inundation. This subsidence and settling however, even after being mitigated/rectified in this rehabilitation project, should not be so severe if it would reoccur, that it would lead to the collapse of the road in a sink-hole like manner, which would give rise to any actionable liability.

On the other hand, the massive earthworks involved with the rehabilitation of the road, including scarifying the existing road surface and shoulders, road pavement removal and replacement, and the transport of earth material from various quarries to the road site; will require major disruptions in the flow of traffic, which if not efficiently managed, may give rise to numerous traffic accidents and consequently liabilities (Table 8.1).

Table 8.1: Geological/Earthworks Impacts and Liabilities.

Geological/Earthworks Impacts	Geological/Earthworks Liabilities
1. Road blockage, diversion, closure.	1. Legal actions for loss of life, limb, health or property from traffic accidents caused by inadequate safety signage; placement of equipment/materials/etc.; directions from signallers, etc.
2. Oil/fuel spillage/leaks from heavy equipment.	2. Legal actions for land contamination – Pollution Regulations non-compliance/Remediation obligations.
3. Siltation of creeks and streams.	3. Legal actions for contamination of BWSL's/ communities' water supply – Pollution Regulations non-compliance.
4. Storage of soils and construction materials.	4. Legal actions for air pollution – Pollution Regulations non-compliance.
5. Mining for construction materials.	5. Legal actions for land degradation – Remediation obligation.

8.3.2 Hydrological/Water Pollution Liabilities

Although the proposed rehabilitation section of the PGH (miles 8.5 – 24.5) traverses the lower sub-catchment of the Belize River watershed, a characteristically flood-prone region of the Belize District, there are no identified liabilities that arise as a result of the road being constructed in this area. Where any section of the road may become flooded, resultant traffic accidents as a result of the flood would not be attributed to the road being built in a flood prone area or as a result of not being climate-change proof to avoid such flooding.

Where liability would arise however, is the massive work that would be involved with the various mitigation measures to alleviate flooding in the area. If not properly managed, this work could lead to the deposition of huge amounts of silt in these water bodies and negatively impact the quality of the water that many communities depend on. In this instance, it is not inconceivable that legal actions could arise on the basis of water pollution claims from individuals using this water (Table 8.2).

Table 8.2 Hydrological/Water Pollution Impacts and Liabilities.

Hydrological/Water Pollution Impacts	Hydrological/Water Pollution Liabilities
1. Discharges of contaminants to receiving waterways (e.g. storm water run-off from elevated gradients on the road and construction camps, run-off from vehicle wash-down areas).	1. Legal actions for contamination of BWSL's/ communities' water supply – Pollution Regulations non-compliance.
2. Disturbance of the Mexico Creek watercourses directly through physical works, and indirectly due to run-off containing suspended solids from removal of stone debris left during the construction of the Mexico Creek Bridge or possible replacement of entire bridge.	1. Legal actions for contamination of BWSL's/ communities' water supply – Pollution Regulations non-compliance.
3. Pollution from spillage of fuel, oils, or cementitious material.	1. Legal actions for contamination of BWSL's/ communities' water supply – Pollution Regulations non-compliance.
4. Vegetation and earth removal, erosion and increased sedimentation into existing water bodies, solid waste pollution, and oil leaks into the soil and ground/surface water, creeks and river during construction of drains and canals.	1. Legal actions for contamination of BWSL's/ communities' water supply – Pollution Regulations non-compliance.

8.3.3 Air Pollution Liabilities

Long-term exposure to high levels of fine particles in the air contributes to a range of health effects, including respiratory diseases, lung cancer, and heart disease; and those responsible for such air pollution may be legally liable.

The construction work involved with the rehabilitation of the PGH will produce substantial air pollution. Quarrying, and its associated activities of excavation, and transportation, and road construction activities have the potential to significantly, adversely affect air quality. The release and dispersion of dust will occur as a result of earth moving operations during site preparation and the transportation of material, movement of heavy construction equipment and traffic. In addition, the operation of heavy machinery will adversely affect air quality through the emission of air pollutants beside the dispersion of dust. As a result, if not properly mitigated, there could be numerous legal claims for respiratory and other health related problems as a result of the air pollution produced by the Project (Table 8.3).

Table 8.3: Air Pollution Impacts and Liabilities.

Air Pollution Impacts	Air Pollution Liabilities
1. The release and dispersion of dust as a result of quarrying and earth moving operations, the transportation of material, movement of heavy construction equipment and traffic; and the emission of air pollutants from the operation of heavy machinery and open fires.	1. Legal actions for health problems in workers and community members such as respiratory diseases, lung cancer, and heart disease – Pollution Regulations non-compliance.

8.3.4 Noise Pollution Liabilities

Noise pollution is an undesired sound that is disruptive or dangerous and can cause harm to life, nature, and property. High noise levels can contribute to noise induced hearing loss, cardiovascular effects in humans, and an increased incidence of coronary artery disease. In animals, noise can increase the risk of death by altering predator or prey detection and avoidance, interfere with reproduction and navigation, and contribute to permanent hearing loss.

Noise related health problems are all actionable and contactors have the responsibility to ensure that all noise emanating from construction equipment and other construction related activities are properly attenuated to avoid such legal liabilities (Table 8.4).

Table 8.4: Noise Pollution Impacts and Liabilities.

Noise Pollution Impacts	Noise Pollution Liabilities
1. Noise from construction equipment, congested highway traffic, quarrying equipment, material transportation vehicles, etc.	1. Legal actions from workers for hearing problems and from community members for noise nuisance – Pollution Regulations non-compliance.

8.3.5 Vibration Liabilities

The effects on vibration on workers and on residences and individuals in the vicinity of the road rehabilitation are both actionable. Workers are exposed to Whole Body Vibration (WBV) and Hand-Arm Vibration (HAV). Whole Body Vibration caused by poorly designed or poorly maintained vehicles, platforms or machinery may cause or exacerbate other health effects such as:

- Lower back pain (damage to vertebrae and discs, ligaments loosened from shaking);
- Motion sickness;
- Bone damage;
- Varicose veins/heart conditions (variation in blood pressure from vibration);
- Stomach and digestive conditions;
- Respiratory, endocrine and metabolic changes;
- Impairment of vision, balance or both;
- Reproductive organ damage.

The longer a worker is exposed to WBV, the greater the risk of health effects and muscular disorders.

Hand-Arm Vibration long term exposure from using hand held tools such as pneumatic tools (e.g. concrete breakers), chainsaws, grinders etc., and causes a range of conditions and diseases, including:

- White finger (also known as “dead finger”) - damage to hands causing whiteness and pain in the fingers;
- Carpel tunnel syndrome (and other symptoms similar to occupational overuse syndrome);
- Sensory nerve damage;
- Muscle and joint damage in the hands and arms (e.g. “tennis-elbow”).
- Rheumatism

Contractors are therefore liable for health problems of workers exacerbated or induced by vibrations and should therefore mitigate these effects by ensuring that workers do not operate vibrating equipment beyond the recommended time periods.

Blasting for road material, piling for bridge foundation/stabilization and heavy vehicle traffic along the road may contribute vibration pollution which may annoy adjacent residents or which may damage homes and other structures. As such, such vibrations are actionable.

Again, it is the responsibility of contractors to ensure that such vibrations are not of such duration as to annoy adjacent residents or such magnitude as to damage adjacent private property (Table 8.5).

Table 8.5: Vibration Impacts and Liabilities.

Vibration Impacts	Vibration Liabilities
1. WBV and HAV impacts on workers.	1. Legal actions for vibration exacerbated/induced health problems in workers.
2. Vibration pollution from blasting for road material, piling for bridge foundation/stabilization, heavy vehicle traffic along the road and construction activities on the ground.	2. Legal actions for vibration nuisance including annoying physical sensations, interference with activities such as sleep and conversation, rattling of window panes and loose objects, and fear of damage to building and contents.

8.3.6 Construction Related Man-Made Hazards Liabilities

Actionable man-made hazards that can impact the Philip Goldson Highway rehabilitation project zone as a result of construction activities include:

- Oil spills,
- Explosions, and
- Chemical fires and spills.

The risk of these man-made hazards increases along the principal highways, with the transportation of fuel, aviation fuel, and LPG. Hazardous substances and material which enter Belize from the western and northern border frequently are transported via the PGH to their final destination within Belize or elsewhere.

As contractors would be liable for any damage or injury occurring as a result of these man-made hazards that result from defective or negligent road construction, they should ensure that they are properly mitigated (Table 8.6).

Table 8.6: Construction Related Man-Made Hazards Impacts.

Construction Related Man-Made Hazards Impacts	Construction Related Man-Made Hazards Liabilities
1. Pollution of water sources from oil spills.	1. Legal actions for contamination of BWSL's/ communities' water supply – Pollution Regulations non-compliance.
2. Loss of life and property from construction related explosions.	2. Legal actions for loss of life and property.
3. Loss of life and property and contamination of air and water resources from chemical fires.	3. Legal actions for loss of life and property and for contamination of BWSL's/communities' water supply – Pollution Regulations non-compliance.

8.3.7 Natural Resources and Environmental Services Liabilities

The main natural resource that the rehabilitation of the PGH in the Project Area would affect is water generally and water quality in particular. This is possible as a result of erosion, silting, and streambed obstruction from construction activities. Areas that are particularly sensitive to erosion and resulting siltation include all culverts and bridge crossings and any expansion of the current Highway footprint, including the proposed construction of a roundabout at the Burrell Boom junction into adjacent wetlands to the East.

As a result, the actionable natural resource and environmental services liability facing contractors is pollution of water resource in and around the Project Area (Table 8.7).

Table 8.7: Natural Resources and Environmental Services Impacts.

Natural Resources and Environmental Services Impacts	Natural Resources and Environmental Services Liabilities
1. Erosion and resulting siltation at all culverts and bridge crossings and any expansion of the current Highway footprint, including the proposed construction of a roundabout at the Burrell Boom junction into adjacent wetlands to the East.	1. Legal actions for contamination of BWSL's/ communities' water supply – Pollution Regulations non-compliance.
2. Redundant side road access points allowing uncontrolled off-site dumping leading to public health risk in encouraging rodents and other pests, risks polluting adjacent wetlands and the water-table, and increases fire risk.	2. Legal actions for contamination of BWSL's/ communities' water supply – Pollution Regulations non-compliance; health problems from public health nuisances; loss of life, limb, health, or property from garbage dump fires.

8.3.8 Social Liabilities

Utility services to communities along the right-of-way of road rehabilitation are expected to be interrupted by construction activities. BWSL water mains across the road sections are located within the road reserve; as such these are completely exposed. To this end, planned service interruptions may be unavoidable and access to water services may be negatively impacted during the construction phase.

In many instances, electric poles fall within the road reserve across the road sections. Planned service interruptions may be unavoidable and access to electricity services may be negatively impacted during the construction phase.

Construction vehicles may put pressure on and negatively impact the public transport and road system across the Project Area; access routes for pedestrians, cars, buses, and trucks could be impeded by construction vehicles thereby increasing travel time for school, work, and business.

While such interruption, if properly planned and executed, are not in themselves, actionable; damage to the privately held portions of these utility infrastructure is (Table 8.8).

Table 8.8: Social Impacts and Liabilities.

Social Impacts	Social Liabilities
1. Private water service infrastructure damage.	1. Legal actions for property damage.
2. Private electricity service infrastructure damage.	2. Legal actions for property damage.
3. Private cable television infrastructure damage (underground fibre optics cable).	3. Legal actions for property damage.
4. Involuntary displacement.	4. Legal actions for temporary/permanent land take and loss of livelihood.
5. Emergency health services denial of access by construction equipment, road closures, etc.	5. Legal actions for loss of life, limb, health, or property.
6. Emergency security services denial of access by construction equipment, road closures, etc.	6. Legal actions for loss of life, limb, health, or property.
7. Unregulated sewage and waste disposed from worksites and work camps.	7. Legal actions for contamination of BWSL's/ communities' water supply – Pollution Regulations non-compliance; health problems from public health nuisances; loss of life, limb, health, or property from garbage dump fires.

8.4 Summary of Environmental Liabilities

The environmental liabilities have been summarized in Tables 8.9 and 8.10. Table 8.9 provides a summary of some those impacts/ potential liabilities associated with the road rehabilitation/ construction activities while Table 8.10 provides a summary for those associated with post construction activities.

Table 8.9: Construction Impacts and Characteristics of Impacts.

IMPACT	DETAILS	IMPORTANCE	MAGNITUDE	EXTENT	PERMANENCE	SPHERE OF INFLUENCE	MITIGABILITY	REVERSIBILITY	PROBABILITY OF OCCURRENCE
Excavation of fill material	Removing fill material from distant locations and transporting it to the site contributing to land degradation and habitat loss off site.	H	H	M	P	W	M	M	H
Deposition/compaction of fill material	Dumping and working fill material at project site to build road bed, reducing porous surface area.	M	Lo	M	P	W	H	Lo	H
Removal and disposal of old surface material	Scraping up and removing old asphalt and concrete from highway surface, improper disposal of this material can result in habitat loss, land degradation, and water quality issues from erosion of materials into waterways and coastal zone.	M	Lo	M	T	W	H	H	H
Erosion and sediment discharge from new roadbed	Fresh sediment created by storm water discharge over newly created areas, depositing materials into water bodies.	H	Lo	La	P	W R	H	H	H
Unnecessary damage to wetlands by heavy equipment	Habitat destruction caused by turning heavy equipment around and by unnecessary road or access building, tread damage, pushing further than necessary into bush areas and riparian zones, cleaning equipment in stream.	H	M	M	T	C W	H	M	H
Unnecessary compaction of soil adjacent to construction site	Movement of heavy equipment and vehicles over soil surface around project site, compacting soil and reducing infiltration rates.	M	S	S	T	C W	H	H	H
Re-diverting stream flow during bridge construction	Changing channel direction of active streams during early wet season, potential damage to riparian forests increasing sedimentation.	H	M	La	T	C W	M	M	H
Construction of drainage ditches along highway	Increased concentrated discharge of storm water, increased erosion of ditch bed, increased sedimentation of river beds.	H	M H	M La	T P	W R	M H	M	H
Application of fresh pavement to road surface	Air pollution from volatile components, storm water erosion of soluble components carried to streams and wetlands that may be toxic to aquatic life.	M	M	M	T	C W	Lo	H	H
Leakage of oil and other	Soluble components carried to streams by storm water discharge	M H	Lo M	S M	T	C W	H	M H	H

fluids from heavy equipment	may be toxic to aquatic life.								
Noise and vibrations	Disturbance of wildlife, disruption of wildlife movement.	M	Lo	S	T	C	Lo	H	H
Dust and exhaust	Air pollution, settling of dust and exhaust into wetlands and waterways by rains, affecting turbidity, acidity and other water quality parameters.	M	Lo	S	T	C W	Lo	H	H
Piles of large waste materials	Concrete, steel, scrap materials, old asphalt cover potential habitat areas, adding leachate from rain water, loss of aesthetics.	Lo	Lo	S	T P	C	H	H	H
Garbage from road workers	Solid waste entering waterways and wetlands, food attracting wildlife to heavy traffic areas, burning releases toxic materials into atmosphere, loss of aesthetics.	Lo	Lo	S M	T	CW	H	H	H
Clearing of Main Drain (Vista Del Mar)	Destruction of habitat from clearing and disposal of cleared material, increased sediment load into receiving water body.	H	Lo	La	P	CW	Lo	Lo	H

Table 8.10: Post Construction Impacts.

IMPACT	DETAILS	IMPORTANCE	MAGNITUDE	EXTENT	PERMANENCE	SPHERE OF INFLUENCE	MITIGABILITY	REVERSIBILITY	PROBABILITY OF
Maintenance of Main Drain (Vista Del Mar)	Disposal of cleared material destroys habitat, increased sedimentation into receiving water body.	H	Lo	La	P	CW	Lo	Lo	H
Discarding of solid waste from passing vehicles	Solid waste in streams and wetlands, creates mosquito breeding sites, lures wildlife to roadside for food scraps, and reduces aesthetic appeal.	M H	M	M	P	CW	H	H	H
Disruption of wildlife movement	Highway reduces movement of many wildlife species, restricts genetic flow, and creates conditions for isolation of small populations.	H	H	La	P	WR	Lo	Lo	H
New development along refurbished highway	Loss of habitat, reduction of wetland areas, reduced flood absorption by land filling, increased pollution from solid and liquid wastes, increased	H	La	M La	P	C W	Lo	Lo	H

	noise, and reduced wildlife movement.								
Sewage discharge from roadside development	Increased nitrification of water bodies, increased algal and aquatic plant growth, increased anaerobic condition.	H	MLa	MLa	T P	C W	H	M H	H
Solid waste from roadside development	Solid waste in water bodies and wetlands, increased mosquito breeding, reduced aesthetics, burning of solid waste introduces toxic materials into atmosphere.	M	M	M	P	C W	H	H	H
Road/drive construction	Increased habitat loss, increased division of wetlands and water bodies, increased sedimentation.	MH	MH	M	P	C	Lo	Lo	H
Continual erosion by storm water discharge	Slope surfaces left un-vegetated will continue to contribute sediment loads to water bodies.	MH	M	M	T P	C W	H	H	H
Disruption of water movement in wetlands by roadbeds	Causes some wetland areas to dry up and others to flood, reduces wetland and water body services, production, and flood control.	H	M	M	T P	C W	M	Lo	H
Habitat destruction	Loss of local biological diversity, degradation of the land, reduced ecological complexity, reduced aesthetics.	H	M	M	T P	C W R	M H	M	H

H, M, Lo — High, Medium, Low for *Importance, Magnitude, Mitigability, Reversibility*, and *Probability of Occurrence*.
S, M, La — Small, Medium, Large for *Extent* [of area] affected
T, P — Temporary, Permanent for *Permanence*.
C, W, N, R — Community, Watershed, National, Regional for *Sphere of Influence*.

8.5 Scoping of Liabilities

A. Liabilities relating to Disturbance of Natural Resources and Ecosystem Services During Road Construction and Operational Phases

A1: **Critical**

A1.1 Erosion, silting, streambed obstruction

Areas that are particularly sensitive to erosion and resulting siltation include all culverts and bridge crossings and any expansion of the current Highway footprint, including the proposed construction of a roundabout at the Burrell Boom junction into adjacent wetlands to the East.

Size and alignment of culverts is critical to functionality: too small or incorrectly aligned culverts can cause significant siltation, creating a positive feedback loop and further slowing flow and increasing sediment deposition and flow blockages. The current bridge crossing at Mexico Creek is a good example of an environmental liability that was not adequately addressed in the previous planning or construction phases, with the raised stream-bed effectively acting as a low dam, and severely impacting the water sink / flood mitigation services previously provided by the Jones Lagoon wetland upstream.

The hydrological assessment report of the current technical assessment is designed specifically to address these remaining negative liabilities associated with the current Highway, and to ensure that the planned upgrading work will more effectively address these issues to minimise and reduce future liabilities.

A1.2 Flood control mechanisms

The water sink / flood control functionalities of the Black Creek – Northern Lagoon and Mexico Creek – Jones Lagoon systems is well known and critical in the moderation of flood events impacting Belize City. Historically, much of the landscape bisected by the Philip Goldson Highway played a role in this flood mitigation, as flood waters dispersed over the interconnected wetlands, savannas and swamp forests and then gradually drained back into the Belize River rather than surging down in huge flood events to inundate the low-lying Belize City area. Some of this functionality has been negatively impacted by the lack of adequate levelling culverts when the highway was first constructed, such that much of the highway effectively acted as a dam, blocking drainage from one side to the other. Subsequent installation of additional and larger culverts has partially rectified these shortcomings, but the upgrade offers the opportunity to mitigate the current issues more comprehensively and effectively.

Corrective actions will require the examination of water levels and flows on both sides of the highway during flood events – to determine where additional or larger levelling culverts are needed to ensure unrestricted water-flow, as well as identifying the height of the culvert bases relative to the drainages. This should also take into account the need to avoid erosion impacts that undermine the road, and road substrate infiltration. Culvert size is often underestimated because of assessment in non-peak flood times – for the Highway, with the importance of the flood control properties of the area, it will be necessary to err on the side of caution and install larger rather than smaller culverts with adequate fallout, particularly with the predicted increase in intensity of storm events.

A1.3 Ecological and landscape damage in natural areas

As detailed in the Environmental Impact Assessment, the Highway bisects a mosaic of savannas and wetlands that have been exposed to significant negative impacts from the original construction of the Highway and other non-related or loosely-related anthropogenic impacts, including widespread fires that significantly reduce species diversity and population densities within these fragile ecosystems. The *incremental* negative impacts from the upgrading of the Highway are assessed as low, but there are localized areas – such as the planned roundabout at the Burrell Boom Junction that may extend some metres into the *Eleocharis* marsh to the east. This dictates that the embankment on the easternmost edge of the roundabout be adequately stabilized to minimize erosion of road substrate into the wetland, and monitoring through the 12-month post-closure period to ensure effectiveness of the mitigation measures.

A1.4 Water pollution

Having been built in the early 1980's, the PGH embankments and shoulders are assessed as being quite stable, with the vegetation of the right of way acting as a biological filtration system that reduces pollution from the road surface runoff reaching the wetlands and creeks close by. The planned upgrade involves some significant vertical realignments to reduce flood risk to the highway. The raised shoulders will require compaction and stabilization to reduce erosion and negative impacts on both the road integrity and water quality in the adjacent wetlands. Where possible, remaining herbaceous ground-cover vegetation between the outer limits of the raised shoulders and the edge of the right of way should be left intact in order to preserve the biological filtration functionality. All drainage ditches should be designed to flow through such vegetated areas before discharging into watercourses or wetlands.

A2: **Non-critical**

A2.1 Uncontrolled off-site dumping

Uncontrolled solid waste dumping was recorded during the assessment, notably in the Los Lagos area of Ladyville. Such dumping poses a public health risk in encouraging rodents sand other pests, risks polluting adjacent wetlands and the water-table, and increases fire risk. This issue will not end with closure of the construction phase and will require ongoing remedial and mitigation activities – including public awareness, signage, enforcement, and possibly gating of unused / redundant side road access points - to limit negative environmental liabilities.

B: **Liabilities relating to Urban Landscape and road infrastructure**

B1: **Critical**

B1.1 Interference with pedestrian or non-motorized traffic that creates safety hazards. Liability on Contractor, MOW, and local authority.

B1.2 Accesses to and from local roads and streets of human settlements blocked by the highway. Liability on local authority and MOW.

B1.3 Improper signage and traffic control during construction that may lead to traffic accidents and loss of life and property. Liability on the Contracting firm and partners.

B1.4 Traffic mishaps and accidents that may results in loss of life and property because of improper design of infrastructure. For example, improper placement or installation of metal guard rails contributing to major crash, loss of life and property (vehicle and infrastructure). Liability lies on the Contractor, MOW.

B2: **Non-critical**

B2.1 Encroachments on the right-of-way. Liability lies with MOW for land acquisition and resettlement.

8.6 Risk Assessment

8.6.1 Hazards

A *hazard* is an agent which has the potential to cause harm to a vulnerable target whether natural or man-induced. Belize is located in an area prone to natural hazards. Foremost among these is the annual occurrence of North Atlantic tropical cyclones and hurricanes that reach the north-western Caribbean or develop over the NW Caribbean area itself. The records also show that Belize is prone to eastern Pacific tropical cyclones that traverse northern Central America and impact the country directly or indirectly. Associated hazards include catastrophic winds, storm surges, torrential rains, flash floods/inundations, and tornadoes. Secondary hazards include but not limited to: source water contamination, increased incidence of water-borne diseases, increased water stressed on road surfaces and bridges, etc.

Secondly, Belize is bordered by three Central American countries that are prone to volcanic eruptions, earthquakes, tsunami, and mudslides. Even though, historically, Belize has not been impacted directly in a major way by these latter occurrences, it has experienced secondary impacts (NEMO, 2010).

Man-made hazard for this section of the highway are primarily those relating to road design, construction and maintenance, accidents, driving practices, pedestrian practices, domestic animal crossings, etc. even wildlife crossings.

8.6.2 Risks

Risk is the potential damage that could arise as a result of the occurrence of a hazard with a given degree of uncertainty. Risk is the probability of occurrence of a hazard.

So a *hazard* is a source of danger, while *risk* involves the likelihood of a hazard developing into some adverse occurrence that may cause loss, injury, or some other form of damage. *Risk* may also be defined as:

Risk = Hazard x Probability of occurrence.

It should be noted that the consequences of *risk* may be contained if safeguards are put in place. However, hazards cannot be reduced unless the hazard itself is removed.

8.6.3 Risk Analysis and Risk Assessment

Risk analysis allows for an evaluation of what *hazard* can occur, the likelihood of its occurrence (probability of occurrence) and the consequences of occurrence.

Risk assessment takes this one step further to address the issue of the importance of these consequences, if they do occur. As can be observed in Figure 8.1, Risk Assessment takes into consideration the likelihood or probability of the hazards occurring and the consequences or impacts. The outcome of the risks may range from very low or insignificant, moderate (minor), High (significant), very high (major risks) to extreme (or severe). Extreme or severe risk category would probability be prohibitively too costly to mitigate and could jeopardize project implementation.

Based on these definitions, it can be seen that *risk analysis* may be carried out in an objective manner, while *risk assessment* is much more subjective.

Another term that must be introduced is that of *Vulnerability*. This is defined as: *the proportion (as a % or as an index from 0 to 1) of what could be damaged (human life, property, etc.) in a given place in the case of occurrence of a given natural phenomenon or hazard.*

			Consequence: How severe could the outcome be if the risk even occur? →				
			1 Insignificant	2 Minor	3 Significant	4 Major	5 Severe
Likelihood	What is the chance of the risk occuring? ↑	5 Almost Certain	5 Medium	10 High	15 Very High	20 Extreme	25 Extreme
		4 Likely	4 Medium	8 Medium	12 High	16 Very High	20 Extreme
		3 Moderate	3 Low	6 Medium	9 Medium	12 High	15 Very High
		2 Unlikely	2 Very Low	4 Low	6 Medium	8 Medium	10 High
		1 Rare	1 Very Low	2 Very Low	3 Low	4 Medium	5 Medium

Figure 8.1: Risk Assessment Matrix (Source: Caribbean Community Secretariat, 2003).

8.7 Incidents Risk Index for Road Construction and Operational Hazards

The **Risk Indices** were determined for road construction and operational hazards/impacts and are outlined in Tables 8.11, according to the hazard's likelihood of occurrence, the severity of the consequences or impacts as posed by the PGH infra-structure rehabilitation activities, and communities in the zone of influence.

Table 8.11: Road Construction Hazards/Impacts Risk Index.

Major Hazards	Likelihood	Consequence	Risk Index
1. **Excavation of fill material**	Almost Certain (5)	Severe (5)	**25** ***Extreme***
2. **Deposition/compaction of fill material**	Almost Certain (5)	Significant (3)	**15** ***Very High***
3. **Removal and disposal of old stripped surface material**	Almost Certain (5)	Severe (5)	**25** ***Extreme***
4. **Erosion and sediment discharge from new roadbed**	Likely (4)	Significant (3)	**12** ***High***
5. **Unnecessary damage to wetlands by heavy equipment**	Likely (4)	Major (4)	**16** ***Very High***
6. **Unnecessary compaction of soil adjacent to construction site**	Moderate (3)	Minor (3)	**9** ***Medium***

7. Re-diverting stream flow during bridge construction	Almost Certain (5)	Major (4)	**20** ***Extreme***
8. Construction of drainage ditches along highway	Almost Certain (5)	Major (4)	**20** ***Extreme***
9. Application of fresh pavement to road surface- leading to water and land pollution	Almost Certain (5)	Major (4)	**20** ***Extreme***
10. Leakage of oil and other fluids from heavy equipment	Likely (4)	Major (4)	**16** ***Very High***
11. Noise and vibrations	Almost Certain (5)	Significant (3)	**15** ***Very High***
12. Dust and exhaust	Almost Certain (5)	Major (4)	**20** ***Extreme***
13. Piles of large waste materials	Almost Certain (5)	Significant (3)	**15** ***Very High***
14. Garbage from road workers	Almost Certain (5)	Significant (3)	**15** ***Very High***
15. Clearing of Main Drain (Vista Del mar)	Likely (4)	Major (4)	**16** ***Very High***
16. Traffic disruption and increased anxiety level for road users, especially during peak traffic periods	Almost Certain (5)	Significant (3)	**15** **Very High**
17. Increased chance of road traffic accidents	Almost Certain (5)	Major (4)	**20** **Extreme**
Post Construction (Operational) Impacts			
18. Maintenance of Main Drain (Vista Del Mar)	Likely (4)	Insignificant (1)	**4** ***Low***
19. Discarding of solid waste from passing vehicles	Likely (4)	Significant (3)	**12** ***High***
20. Disruption of wildlife movement	Almost Certain (5)	Major (4)	**16** ***Very High***
21. New development along refurbished highway	Almost Certain (5)	Significant (3)	**15** ***Very High***
22. Sewage discharge from roadside development	Likely (4)	Major (4)	**16** **Very High**
23. Solid waste from roadside development	Almost Certain (5)	Significant (3)	**15** **Very High**
24. Road/drive construction	Almost Certain (5)	Major (4)	**20** **Extreme**
25. Continual erosion by storm water discharge	Likely (4)	Major (4)	**16** **Very High**
26. Disruption of water movement in wetlands by roadbeds	Likely (4)	Major (4)	**16** **Very High**
27. Habitat destruction	Almost Certain (5)	Major (4)	**20** **Extreme**
28. Disruption of BWSL Water Mains	Likely (4)	Major (4)	**16** **Very High**
29. Severing of BTL Fibre Optics Cables	Likely (4)	Major (4)	**16** **Very High**
30. Link Canal facilitating saline wedge farther upstream on the Belize River, affecting water quality for Crystal Bottling Company, BWSL Water Production Plant Intake facilities, and	Almost Certain (5)	Severe (5)	**25** **Extreme**

other stakeholders, especially during dry season.			
31. Raised PGH and improperly constructed drainage, resulting in localized flooding problems for adjacent property owners in zone of influence.	Likely (4)	Major (4)	**16 Very High**

8.8 Risk Associated with Natural and Man-made Hazards

8.8.1 Hydrometeorological Risks, Hazards

Table 4 below is a matrix of major hydrometeorological – geophysical and anthropogenic-related hazards that have been experienced in Belize. The major hydrometeorological hazards that can impact the PGH project site are: Tropical cyclones and related hazards such as torrential rains, coastal floods, and inundations (pluvial i.e. rainfall related-and riverine floods), destructive winds, storm surge and tornadoes; droughts and heat waves.

8.8.2 Geophysical hazards

May include earthquakes and landslides/mudslides or slippage, and tsunami.

8.8.3 Man-made Hazards

Man-made hazards that can impact the Philip Goldson Highway rehabilitation project zone include:

- Chemical Fires and Spills,
- Oil Spills,
- Road Traffic accidents, and
- Aircraft crash (rare, but could happen in the area).

The risk of these man-made hazards increases along the principal highways, with the transportation of fuel, aviation fuel, and LPG. Hazardous substances and material which enter Belize from the western and northern border and the Belize City Port/Big Creek Port, are frequently transported via the PGH to their final destination within Belize or elsewhere.

8.8.4 Impacts

Impacts caused by natural or man-made hazards on communities or infrastructure are evaluated through *risk analysis* and *risk assessment* that determine the consequences and importance of the impacts and hence the intensity of the hazards.

Table 8.12 provides a summary of the major natural and man-made hazards the Philip Goldson Highway zone of influence is exposed to, their frequency, and the corresponding impacts and proposed mitigation measures.

Table 8.12: Hazards and Elevated Risks to People and Assets in the Zone of Influence of the Philip Goldson Highway.

Hazards	Frequency	Specific Impacts	Adaptation Measures
Tropical Cyclones	1 – 2/yr during 15-year TC active cycle; 1/10 yr during 15-year TC inactive cycle (e.g. during the period 1980-1994).	High winds: demolish housing, infrastructure, commercial, and household assets and crops/livestock; Wave Energy & Storm Surge: inundates coastal areas, destroy property (piers & marinas), and degrades coast and cayes. Floods & Inundations: drowning of people and livestock; destroys property, crops, and infrastructure including roads & highways; contaminates water sources. High Winds: down power lines and poles, partial or total roof and wall failure; flatten crops and fruit trees, breaks and denudes swap of forest along storm path.	Contractors are to develop and review Hurricane Emergency Plans (HEPs) with staff. Contractors must be familiarized with MOW's and Forest Department HEPs and SOPs for addressing bush fire threats. Ensure proper, high quality engineering works is carried out during road re-construction, surface sealing, and drainage that is resistant to extreme weather events and other hazards. MOW's Risk Management Plan (RMP) should address road failures, bridge and culvert inspections and upkeep, and refurbishment and maintenance of drainage and canals. Regular inspection carried out by MOW's engineers during bridge construction, and culverts installation. MOW's RMP will be up and running for road infrastructure inspection and maintenance during future operational period.
Storm Surge and Coastal Flooding	Coastal Flooding are annual events. Predicted storm surges for 2-year and 100-year return periods range from 0.2 to 6.5 m (Golder Associates Ltd., 2017)	Frequent occurrence in the ROW of the PGH. Pluvial flood hazard elevates risk to people and livestock drowning; destroys property, crops and infrastructure including roads & highways; undermines bridge aprons; contaminates water sources; disrupts commerce; affects livelihood and increase rate of erosion and sedimentation.	Engineering designs for road rehabilitation, by-passes or alternate routes and bridges must meet standards for resilience to extreme hydro-meteorological conditions. During road construction protective barriers must be put in place to control erosion and sedimentation of loose road materials into streams and channels. MOW's Road Rehabilitation Programme should be funded and implemented as part of the Ministry's annual work plan.
Inundations	Major inundations or flood events have cycle of 15 – 20 year, shorter period during 15-year cycle of increased ACE[2] in a warmer climate and an energized	Floods & Inundations: drowning of people and livestock; destroys property, crops, and infrastructure including roads & highways; contaminates water sources; disrupts commerce; affects people's livelihood. Increase the incidence of water-borne diseases; put additional economic stress on health services and emergency response;	Engineering designs for road rehabilitation, by-passes or alternate routes and bridges must meet standards for resilience to extreme hydro-meteorological conditions. MOW has effective Creek and Channel cleanup programme in place.

	water cycle.	reduce productivity and affect GDP.	
Droughts and Bush Fires	*Very Likely* (1 in 10 Years in the case of severe droughts) *Very Likely* (Annually in the case of Bush and Coastal Savannah Fires)	Loss of crops and livestock. Impairs livelihood. Reduce availability of freshwater. Flow volumes reduced to base flow in streams and rivers. Reservoirs levels may drop to below critical values. Capacity may be insufficient to generate energy. Forest fires during construction may disrupt progress and threaten human life. PGH traffic and maintenance crew may be directly affected by forest fires and smoke inhalation. Reduction in visibility	A National Plan for Drought Emergency should be developed by the MNRA in conjunction with NEMO and Farming Communities. Forest Department should review Forest Fire Plan and conduct regular bush fire drills, in preparation for Fire Season (15 Feb – 31 May).
PMF[1]-Dam Break	*Rare (1 in 500 years)*	Worst case scenario of a dam failure will cause a sudden but short-lived rise in water level as it spread across the flood plain downstream of the Hawksworth Bridge to Roaring Creek and beyond. Many section of the downstream PGH will become inundated. Upstream in the Upper Macal, a PMF will likely take away the Mollejon and Vaca Hydroelectric facilities and inundate the downstream flood plains to record levels.	BECOL "Alerts" of dam spillage and high capacity water release", need to disseminate nationally on a "timely" basis to all stakeholders and the general public. Signage of flood evacuation route updated, maintained, and clearly displayed.
Earthquake	*Rare in the Zone of Influence of the PGH* (1 in 20 years) moderate	Houses and infrastructure failure. The May 2009 seismic event originating in the Gulf of Honduras directly impacted the coastal community of Monkey River; other areas affected but to a lesser degree, Two bridges in	Bridges and highway construction designs should consider this.

		the Belize River Valley were affected!	
Chemical fire & spill	*Moderate*	May result in loss of human life Disrupt traffic; may pollute surface water bodies	Contractors must have and implement Standard Operation Plan (SOP) for chemical fire and spill of hazardous material and have a liaison identified to communicate and report incidents to Police, DOE, and Fire Dept. immediately and act as first responders.
Oil spills	*Moderate*	May result in loss of human life Disrupt traffic; may likely pollute surface water sources.	Contractors must have and implement Standard Operation Plan (SOP) for chemical fire and spill of hazardous material and have a liaison identified to communicate and immediately report incidents to DOE and act as first responders.
Explosion	*Rare*	Loss of human life. Disrupt traffic.	Contractors must have and implement Standard Operation Plan (SOP) for chemical fire and spill of hazardous material and have a liaison identified to communicate and report incidents to Police, DOE, and Fire Dept. immediately and act as first responders.
Major road traffic accident & Aircraft crash	Road Traffic accidents: *Extremely Likely* Aircraft accidents: *Rare occurrence*	Loss of human life. Disrupt traffic, especially in sections of the PGH where there is no designated detour. Disrupt electric grid, may start bush and savannah fire.	Implement proposed new, Mass Transport Master Plan. Ensure traffic laws and regulations are in place. Sensitize road users (Transport Department). Train first responders for mass casualty emergency and evacuation.
Infra-structure failure	*unlikely*	Loss of human life and public assets; impacts production, economic growth and GDP. Disrupts or slowdown traffic.	Ensure new construction of road infrastructure follows international standards for safety and strength (e.g. Roadway should be designed to withstand and properly drain a one in 50 year storm event, and bridges should withstand a one in 100 year storm (i.e. Hurricane Mitch 1998 event). MOW should ensure that all new infrastructures will be built according to specification for High standard and safety. MOW should establish an efficient Road Maintenance Unit and a Road Maintenance Fund (RMF).

[1] PMF Probable Maximum Flood [2] ACE Accumulated cyclone energy

8.8.5 Risk Index for Natural and Man-made Hazards

The **Risk Index for natural and man-made hazards** were determined according to the hazard's likelihood of occurrence, and the severity of the consequences or impacts as posed to the PGH infra-structure rehabilitation, and communities in the zone of influence. The result of this evaluation is summarized in Table 8.13 below.

Table 8.13: Natural and Technological Hazard Risk Index.

Major Hazards	Likelihood	Consequence	Risk Index	Liability
Tropical Cyclones & Hurricane	Almost Certain (5)	Severe (5)	**25** ***Extreme***	USD - Millions to road Infrastructure. Loss of life
Pluvial floods, Inundation & Storm Surge	Likely (4)	Major (4)	**16** ***Extreme***	USD - Millions to road Infrastructure. Loss of life.
Dam Break	Rare (1)	Severe (5)	**5** ***Medium***	USD - Millions to road Infrastructure & communities. Loss of life.
Wild Fires	Almost Certain (5)	Significant (3)	**15** ***Very High***	Loss of biodiversity and property.
Heat Waves	Likely (4)	Significant (3)	**12** ***High***	Resulting from heat stress.
Earthquakes	Moderate (3)	Minor (3)	**9** ***Medium***	Loss of life and property.
Subsidence	Likely (4)	Minor (3)	**12** ***High***	Infrastructure damage.
Traffic accidents	Likely (4)	Major (4)	**16** ***Extreme***	Loss of life & property.
Oil Spills	Moderate (3)	Significant (3)	**9** ***Medium***	Contamination of water and ecosystems.
Explosion (Road Construction & mining)	unlikely (2)	Significant (3)	**6** ***medium***	Impact on ecosystem/communities.
Chemical Fires	moderate (3)	Minor (2)	**6** ***Medium***	Impact to environment.
Air Transport Accidents	Rare (1)	Severe (5)	**5** ***Medium***	Loss of life and property.

8.9 General Road Construction Risk and Responsibility

After risks have been identified, it becomes necessary to consider the effect on the road rehabilitation project. Design and construction risk can be passed down to the design and construction contractor, and operation and maintenance risks can, to a large extend, be assumed by the operations and maintenance contractors. Certain risks can be borne by the insurance market. Additionally, some risks are uninsurable and may have to be borne by the Government. Risks also arise in road design, construction, force majeure risks, Operations & Maintenance (O&M) risks, performance risks, and others.

Table 8.14 provides a road risk matrix covering other possible liabilities related to the Philip Goldson Highway rehabilitation project.

Table 8.14: General Road Risks Matrix.

Type of Risks	Risks	Comments
Design Risk	Feasibility approval and consent by MOW.	Environmental approvals: Archaeological issues; Utilities; Approvals for complementary facilities such as work camps.
Design Risk	Working (Construction) drawings delay in final approval of detailed design.	Could result in increased cost of design or delay of project. Where Grantor approves detailed design, then compensation warranted for unreasonable delay in approval.
Design Risk	Changes in design and construction standards during the construction period.	This depends upon the reason for the change. If original design was inefficient, then it's the Contractor's risk or that of the engineering firm.
Site Risk	Land acquisition within right-of-way (ROW).	GOB has the right to acquire land for road construction purpose at market value, but may need to arrive at compromise for inflated value proposed by owners. This could be a risk to the project. Problems with encroachment on ROW may elevate project cost.
Site Risk	Obtaining consents to use additional land (permanent additional ROW).	May cause delay in obtaining additional consents.
Site Risk	Obtaining Ministerial or owner consent to use additional land (temporary use of land for construction purposes)	Is the land essential or just desirable? If it is the former, then it is the responsible of MOW to assist; may require GOB to exercise compulsory purchase or land acquisition.
Site Risk	Access risks; Access to the corridor from local roads or worksites.	Access risks relates to existing connecting roads to project site. Volume risks could be an issue, as well as risks resulting from damage to access roads.
Site Risk	Construction site security-Protection from interference.	May be required near schools and other public areas frequented by public. Communities support for road rehabilitation reduces risk.
Site Risk	Cultural / archaeological heritage.	Guided by legislation. Covered in the ESIA.
Site Risk	Environmental.	Pre-existing conditions will be the responsibility of GOB risk, unless remediation can be assessed in advance. New Risks due to road rehabilitation will be responsibility of

		Contractor if he does not comply with mitigation measures.
Site Risk	Geotechnical and ground/soil condition.	Must be considered in road design to reduce risk.
Site Risk	Water/air/soil pollution ─ unknown pre-existing.	Remediation cost can be very substantial particularly if mitigation measures are not strictly implemented. Contractor may have to bear the risk.
Site Risk	Undisclosed latent defects.	This risk could be a time shifting of expenditure from O&M to reconstruction/rehabilitation phase.
Construction Risk	Quality assurance and quality control.	Responsibility of the Contractor/MOW supervision.
Construction Risk	Achieving construction standards and specification.	-Standards: requirement by MOW - If Specifications: requirement not met the risk is the responsibility of the contractor.
Construction Risk	Cost over- run and delay not caused by a relief or compensation event.	Liability may lie with PMU/MOW/Contractor.
Construction Risk	Delays caused by agencies other than MOW (e.g. Utilities).	Responsibility remains that of MOW
Construction Risk	Delays caused by GOB- Failure of GOB to perform its obligation.	Mechanism to allow both extension of time to Concessionaire/Contractor to complete the construction obligation and grant compensation to Concessionaire. In extreme cases may give rise to termination.
Construction Risk	Delay due to changes required by MOW.	Any changes initiated by the Grantor. This may have capital cost implications but may also affect O&M cost.
Construction Risk	Labour disputes.	Contractor risk. Liaise with Labour Department.
Construction Risk	Labour and material availability.	Unless due to GOB's intervention, may need to consider import risks.
Construction Risk	Project management/integration delay.	MOW's PMU will manage project. Cost of delay may be shared risk if the new structure is dependent on work being completed by public sector.
Construction Risk	Damaged to works, however caused except excluded.	Insurable. Contractor to seek damages from liable party. If other government agency causes damages when exercising rights to project road, they would be liable but may be covered by insurance.
Construction Risk	Damage/injury to third parties.	Should be covered by insurance and will be at risk of Contractor, unless caused by MOW or other government agency.
Construction Risk	Damage/loss to utilities identified by Grantor.	MOW enters into agreement with utilities.
Construction Risk	Damage/loss to utilities not identified by MOW.	If utility company has not identified the utilities then it ought to be responsible for the costs associated to damages, however, MOW may have to assume preliminary liabilities.
Construction Risk	Sub-contractor insolvency.	Contractor will bear the risk.
Construction Risk	Latent defects (new infrastructure and disclosed defects with existing infrastructure).	Contractor should be liable and should remove or correct defects. If latent defects not found until later years into O&M period, then it is most likely to be MOW responsibility.
Construction Risk	Defective materials.	Responsibility of Contractor.
Construction Risk	Injunctions against construction due to alignment.	If corridor chosen by MOW, then MOW assumes responsibility.

Construction Risk	Work place health and safety.	Contractor risk.
Construction Risk	Construction security (bonding requirement).	Adequate bonding in place for subcontracts.
Force Majeure Risk	Natural disasters	Depends upon the availability of insurance. Performance Specification should detail what weather conditions should be planned for.
Force Majeure Risk	Intensive and extended event leading to termination.	GOB payment could be offset by the insurance received.
Performance Risk	Labour and material availability.	Contractor's risk.
Performance Risk	Change in scope of service specifications by public service.	Increased expenditure should be borne by Grantor/GOB/MOW.
Performance Risk	Damage caused by road users.	Insurance of liable road user. MOW responsibility.
Performance Risk	Damage to works however caused, except as excluded.	Insurable.
Performance Risk	Water/air/soil pollution.	If caused by Contractor, then Contractor liable.
Performance Risk	Third party claims and accidents.	Should be insured against.
Performance Risk	Traffic accidents.	Traffic accidents: If Contractor responsible, Contractor cost, otherwise, liable party pays.
Performance Risk	Off road accidents.	Incidents that affect the operations of the road but are not related to traffic accident. Liable party pays.
Performance Risk	Work place health and safety.	Including emergency measures responsibility of Contractor.
Performance Risk	Obtaining and maintaining licenses to comply with regulatory requirements	Responsibility of Contractor.
Performance Risk	Labour disputes.	Risk of Contractor.
Performance Risk	Traffic management.	Depends on scope of traffic- usually the responsibility of contractor however may require police involvement.

CHAPTER 9: ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

9.1 Environmental Management Plan (EMP)

This section of the Environmental and Social Impact Assessment (ESIA) Report provides a summary of the recommended mitigation measures aimed at addressing the potential environmental impacts the project could have on the environmental and social setting of the study area. In most cases, it is possible to reduce potential adverse impacts to the point where the impacts are insignificant or negligible, either through effective design, the use of green technologies and best practices or through sound operational management of the road rehabilitation project and its accompanying activities.

The key in any successful mitigation measure is to adequately identify the potential negative impacts and their implications and to develop a supporting environmental management plan. The proposed environmental and social management plan is based on the identification and implementation of effective management tools and best practices accompanied by a process of monitoring and constant improvements. The implementation of environmental management standards, best practice, and the use of established protocols is important in helping to reduce environmental impacts as measured by some objective criteria. Thus, the environmental management plan proposed for this road rehabilitation project and supporting activities involves the close integration of the following:

1. *Environmental Impact Mitigation Plan* – Impact mitigation is the most critical component of the environmental study process. It aims to prevent adverse impacts from occurring and keeps those that do occur within an acceptable level.

2. *Environmental Monitoring* – Environmental monitoring provides information that can be used for documentation of the residual impacts that result from the construction and operational activities. This information enables more-accurate prediction of the associated impacts and the necessary feed- back mechanism essential in adjusting the EMP. Therefore, the monitoring system is a platform of measuring projected impacts and also in identifying unanticipated adverse impacts or sudden changes in impact trends essential in the implementation of an environmental management program based on the concept of constant improvement.

9.1.1 Environmental Impact Mitigation Measures

Identifying the appropriate mitigation measure for an identified impact must take into consideration its cost- effectiveness as these have the potential for significant financial implications. The outcome however must effectively address the impact with little or no residual repercussion to the environment. Thus, there will be continuous mitigation measures throughout the project's cycle that will be implemented to protect and conserve the environment and social setting of the study area as best as possible.

Considering the continuous improvement in impact mitigation, the implementation of the project's EMP will have as its objectives to:

1) find better alternatives and ways of doing things;
2) enhance the environmental and social benefits of the road rehabilitation project;
3) avoid, minimize or remedy adverse impacts; and
4) Ensure that residual adverse impacts are kept within acceptable levels.

9.1.2 Mitigation Plan for Environmental Impacts

Table 9.1 provides a summary of the proposed mitigation measures to ameliorate the negative impacts of the Environmental issue identified in the impact assessment section of the ESIA. It is important to take note that the potential impacts of the road rehabilitation activities are significantly reduced since much of the related activities would be occurring within an already existing highway corridor. This table forms the basis of the environmental and social management plan in a summarized form.

Table 9.1: Summary of the Proposed Mitigation Measures.			
GEOLOGY			
Mitigation Measure(s)	**Monitoring Indicator(s)**	**Monitoring and Reporting Frequency**	**Party(ies) responsible**
Activity: 1. Earth movement excavation low lying areas and raising highway			
Impacts: 1. Subsidence			
1. Use geotextile in low lying areas; maintain a slope of no more than 1:3 ratio.	Engineering instrumentation proof to be provided.	Monitor monthly and quarterly	PMU and Contractor
Impacts: 2. Sedimentation of wetland or water body			
1. Grass slopes and use check-dams to control siltation of wetlands.	Visual inspections.	Monitor monthly and quarterly	PMU and Contractor
Activity: 1. Earth movement while constructing new bridge (Mexico Creek)			
Impacts: 1. Siltation			
1. Diversion of storm water from construction area.	Visual inspections.	Monitor weekly and report monthly	Contractor/ PMU
2. Use of check dams along storm water drains.	Visual inspections.	Monitor during construction activities	Contractor/ PMU/DOE
3. Use of wing dams made of sand bags or use of silt curtains.	Visual inspections.	Monitor during construction activities	Contractor/ PMU/DOE
4. Works to take place during dry periods.	Visual and documentary proof to be provided.	Monitor weekly and report monthly	Contractor/ PMU/DOE
Activity: 2. Earth movement while mining materials at quarry pits			
Impacts: 1. Man induced land denudation			
1. Material volumes extracted from different sites.	Visual and documentary proof to be provided.	Monitor weekly and report quarterly	PMU/DOE
Impacts: 2. Ponding			
1. Extraction sites levelled evenly.	Visual inspections.	Monitor weekly and report quarterly	Contractor/ DOE
2. Rehabilitate all verges on completion of works.	Work logs and site inspections.	Quarterly	Contractor/ PMU, DOE

HYDROLOGY			
Mitigation Measure(s)	**Monitoring Indicator(s)**	**Monitoring and Reporting Frequency**	**Party(ies) responsible**
Activity: 1. Construction activities through Ladyville and Lords Bank area			
Impacts: 1. Pollution of wetlands, issues with dust, noise and traffic.			
1. Install barriers/curtains / prevent accidental spills. Store stripped surface material away from water source limit noise around schools; divert traffic away from area as recommended.	Visual inspections and laboratory testing of nearby water bodies.	Monitor weekly and report monthly	Contractor/ PMU/DOE
Activity: 2. De-watering/ watering work for structure foundations/ earthwork operations			
Impacts: 1. Water Pollution			
1. Construction of intercepting ditches, by-pass channels, barriers, settling ponds, silt sumps, highway oil interceptors, and interceptor grates.	Visual inspections and laboratory testing of nearby water bodies.	Monitor weekly and report monthly	Contractor/ PMU/DOE
Activity: 3. Discharge of waste water			
Impacts: 1. Pollution of streams, watercourses and other surface waters			
1. Discharge wastewater into temporary settling ponds/similar structures.	Visual inspections and laboratory testing of nearby water bodies.	Monitor weekly and report monthly	Contractor/ PMU/DOE
Activity: 4. Storage of waste oil, grease and other contaminants at workers camps and other sites			
Impacts: 1. Pollution of streams, watercourses and other surface waters			
1. Proper storage facilities in all construction camps.	Visual inspections, documentary proof to be provided and laboratory testing of nearby water bodies.	Monitor monthly and quarterly	PMU and Contractor
Activity: 5. Storm water runoff during construction			
Impacts: 1. Pollution of wetlands and other surface waters			
1. Diversion of storm water to temporary, natural settling ponds.	Visual inspections and laboratory testing of nearby water bodies.	As required	PMU/DOE
Activity: 6. Mining fill materials from burrow sites			
Impacts: 1. Ponding and damming of natural waterways			
1. Provide for free drainage following extraction.	Visual inspections.	Monitor weekly and report monthly	Contractor/ PMU/DOE
Activity: 7. Storing stripped pavement and excavated soil			
Impacts: 1. Pollution of wetlands and water bodies			
1. Store all stripped pavement and excavated soil away from wetlands and water bodies.	Visual inspections.	Monitor weekly and report monthly	Contractor/ PMU/DOE

DISASTER RISK MANAGEMENT			
Mitigation Measure(s)	**Monitoring Indicator(s)**	**Monitoring and Reporting Frequency**	**Party(ies) responsible**
Activity: 1. Extreme hydro-meteorological events in the form of flash floods, inundations, and high-winds associated with the passage of tropical cyclones and hurricanes.			
Impacts: 1. Land use changes in the sub-basins and micro catchments of the GBRB which changes the hydrology of the catchments resulting in flooding from increased runoff, increased siltation, and clogging of channels and culverts.			
1. Install minimum 24-inch diameter, ferro concrete culverts and properly designed inlets-outlets and outflows	Visual inspections and engineering instrumentation verification.	Monitor monthly and quarterly	PMU and Contractor
2. Design, construct, and maintain drains to minimize ponding and overflow onto highway or inundate private property.	Visual inspections and engineering instrumentation verification.	Monitor quarterly and report annually	PMU/DOE
3. Construct drainage along all realigned sections to avoid damming or obstruction of surface runoff on either side of road.	Visual inspections and engineering instrumentation verification.	Monitor monthly and quarterly	PMU and Contractor
4. Stabilize channel sides and road shoulders to avoid slippage or landslide during torrential rain events.	Visual inspections and engineering instrumentation verification.	Monitor monthly and quarterly	PMU and Contractor
5. Ensure that the approaches to Mexico Bridge and its deck are above the maximum flood stage.	Visual inspections and engineering instrumentation verification.	As required	PMU/DOE
6. Regularly maintain Mexico Creek, Black Creek, and Mussel Creek stream channels, culvert outlets and discharge and drains.	Visual inspections.	Monitor quarterly and report annually	PMU/DOE
7. Keep high vegetation cleared along PGH ROW.	Visual inspections.	Monitor quarterly and report annually	PMU/DOE
8. Use of "double chip seal and concrete" for pavement to withstand rainfall, floods, inundation and extreme heat.	Visual inspections and engineering instrumentation verification.	Monitor monthly and quarterly	PMU and Contractor
9. Use concrete surfacing where lifting of road is impractical and sections will still be subject to period flooding	**Visual inspections and engineering instrumentation verification.**	**Monitor monthly and quarterly**	PMU and Contractor

NOISE			
Mitigation Measure(s)	**Monitoring Indicator(s)**	**Monitoring and Reporting Frequency**	**Party(ies) responsible**
Activity: 1. Construction activities such as ground-disturbing activities, clearing and grubbing, excavation and grading work, installing shoring, jack hammering, pile driving, blasting, rock crushing etc.			
Impact: 1. Environmental Effects: Noise above tolerable levels. Maximum to protect against hearing loss: 70 dBA			
1. Ensure that construction works are only undertaken in defined working hours (not exceeding 12 hrs). 2. Should noisy activities are undertaken outside of the specified working hours, affected stakeholders will be informed of such activities in advance.	Visual and auditory inspections and documented proof of working hours. Complaints by stakeholders.	Monitor weekly. Assess and manage all noise complaints. Undertake noise monitoring at locations with persistent noise complaints. Report monthly.	Contractor/ PMU/DOE
3. Restrict extent of noise impacts temporally – not working on entire road length at any one time. This also allows sensitive species to cross at quieter sections and reduce impacts on residents along the PGH.	Visual inspections and engineering instrumentation verification.	As required	Contractor/ PMU/DOE
4. Construct noise barriers between work sites and communities, especially schools zones.	Installation of noise barriers. Visual inspections and engineering instrumentation verification.	As required	Contractor/ PMU/DOE
5. Ensure that equipment to be used meets industry best standard in relation to noise attenuation.	Visual and auditory inspections.	Carry out regular checks on site equipment to ensure it is running smoothly and efficiently	Contractor/ PMU/DOE
6. Ensure that all vehicles and motorized equipment are turned-off while not in use.	Visual and auditory inspections.	Carry out regular checks on site equipment that all vehicles and motorized equipment are turned-off while not in use.	Contractor/ PMU/DOE

NOISE			
Mitigation Measure(s)	**Monitoring Indicator(s)**	**Monitoring and Reporting Frequency**	**Party(ies) responsible**
7. Limit work vehicles to designated access and work site areas.	Installation of signages as appropriate.	Before construction, works begin and during the project implementation, appropriate signages should be put in place.	Contractor/ PMU/DOE
Activity: 2. Operating construction vehicles such as trucks, tractors, excavators, etc.			
Impacts: 1. Noise above tolerable levels. Maximum to protect against hearing loss: 70 dBA			
1. Ensure that construction works are only undertaken in defined working hours (not exceeding 12 hrs).	Visual inspections, documented proof of working hours Complaints by stakeholders.	Monitor weekly. Access and manage all noise complaints. Undertake noise monitoring at locations with persistent noise complaints. Report monthly.	Contractor/ PMU/DOE
2. Maintain construction vehicles and motorized equipment fitted with mufflers where appropriate; turn off when not in use; avoid excessive reversing.	Visual inspections and documented complaints from stakeholders.	Monitor weekly and report quarterly	Contractor/ PMU/DOE
3. Erect the appropriate signage discouraging the use of vehicle horns when travelling through residential areas	Installation of signages as appropriate	Before construction works begin and during the project implementation, appropriate signages should be put in place.	Contractor/ PMU/DOE
4. Avoid excessive Compression Release Engine Braking (Jake Braking) by diesel trucks so equipped in populated areas.	Operators are conversant with the policy	Operators abiding by the policy.	Contractor/ PMU/DOE

VIBRATIONS

Mitigation Measure(s)	Monitoring Indicator(s)	Monitoring and Reporting Frequency	Party(ies) responsible
Activity: 1. Operating construction vehicles, equipment and tools			
Impacts: 1. Back injury to workers from whole body vibrations			
1. Use vibration isolation and suspension systems. Practice job rotation, rest periods, and reduction in the intensity and duration of exposure.	Visual inspections. *Sensitise ALL personnel of the potential vibration hazard.*	As required.	Contractor/ PMU/DOE
Activity: 2. Operating construction vehicles, equipment and tools			
Impacts: 1. Damage to property in vicinity and along ROW			
1. Assess vibration impacts to property and discontinue where damage is imminent.	Documented complaints from stakeholders.	Assess and manage all complaints. Undertake vibration monitoring at locations where damage is imminent.	Contractor/ PMU/DOE

AIR

Mitigation Measure(s)	Monitoring Indicator(s)	Monitoring and Reporting Frequency	Party(ies) responsible
Activity: 1. Earth movement operations such as ground-disturbing activities, clearing and grubbing, excavation and grading work, transportation of materials and operation of heavy machinery			
Impacts: 1. Release and dispersal of dust			
1. Use dust suppressant measures.	Visual inspections and documented complaints from stakeholders.	Monitor as required. Report monthly	Contractor/ PMU
2. Avoid haulage of materials through residential areas whenever an alternative route is feasible and ensure loads are covered.	Visual inspections and documented complaints from villagers.	As required. Report quarterly.	Contractor/ PMU
3. Regularly water haul routes in sensitive areas during dry periods.	Visual inspections and documented complaints from villagers.	As required. Report quarterly.	Contractor/ PMU
4. Store dusty material in appropriate locations.	Visual inspections and documented complaints from villagers.	As required. Report quarterly.	Contractor/ PMU
5. Limit and enforce speed around construction zone.	Installation of signages as required. Visual inspections.	Monitor daily. Report monthly.	Contractor/ PMU

AIR

Mitigation Measure(s)	Monitoring Indicator(s)	Monitoring and Reporting Frequency	Party(ies) responsible
1. Erect dust barriers near schools and sensitive areas.	Installation of dust barriers. Visual inspections and engineering instrumentation verification.	As required. Report monthly.	Contractor/ PMU
2. All areas disturbed during construction that are not required for a specific activity must be re-vegetated.	Disturbed areas re-vegetated.	As required. Report monthly.	Contractor/ PMU
Activity: 2. Operating construction equipment			
Impacts: 1. Dispersal of dust			
1. Shut off equipment when not in use and maintain in good operating condition.	Visual inspections and documented complaints from stakeholders.	Monitor daily. Report monthly.	Contractor/ PMU/DOE
2. Ensure equipment has emission control devices.	Visual inspections and engineering instrumentation verification.	Monitor weekly. Report monthly.	Contractor/ PMU/DOE
3. Construction vehicle exhaust emissions from heavy machinery on site (excavators, front-end loaders, and hauling trucks) must be controlled and minimized.	Visual Inspection.	Regular checks and servicing of vehicles. Any construction vehicle found to be emitting excessive smoke must be stopped from the operations for some mechanical attention before it could continue.	Contractor/ PMU/DOE

Water Pollution

Mitigation Measure(s)	Monitoring Indicator(s)	Monitoring and Reporting Frequency	Party(ies) responsible
Activity: 1. Construction activities near flood prone areas, creeks, lagoons and near the river			
Impacts: 1. Water pollution			
1. Minimize problems with soil erosion and sedimentation from earth moving activities or debris removal while conducting the cleanup of the Mexico Creek, Mussel Creek, and Black Creek.	Employing BMPs for soil erosions as recommended in the section on geology.	Monitor weekly. Report monthly.	Contractor/ PMU/DOE
2. Construction activities should be managed to prevent entrance, or accidental spillage of solid matter, contaminants, debris and other pollutants and wastes into streams and watercourses.	Visual Inspection	Monitor weekly. Report monthly.	Contractor/ PMU/DOE
3. Construct intercepting ditches, check dams, wing dams, siltation curtains, by-pass channels, barriers, settling ponds, silt sumps, highway oil interceptors, and interceptor grates.	Visual inspections and laboratory testing of nearby water bodies.	Weekly inspections and report quarterly.	Contractor/ PMU/DOE

Water Pollution			
Mitigation Measure(s)	**Monitoring Indicator(s)**	**Monitoring and Reporting Frequency**	**Party(ies) responsible**
4. Ensure responsible storage and handling of petroleum products and maintain equipment free from oil and fuel leaks. Implement a zero-tolerance policy for fuel, oil, hydraulic fluids spillages	Visual inspections and documentary proof provided.	Weekly inspection report monthly	Contractor/ PMU/DOE
5. Maintain equipment in good operational condition, free from any oil and fuel leaks.	Visual Inspection	Monitor weekly. Report monthly.	Contractor/ PMU/DOE
6. Maintain spill clean-up kits and report spills to DOE.	Visual inspections and documentary proof provided.	As required	Contractor/ PMU/DOE
7. Erect aboveground fuel tank in bunded area, store waste oil in sealed containers, and contact DOE for disposal.	Visual inspections and documentary proof provided.	As required	Contractor/ PMU/ DOE
8. Ensure that the area is kept free from litter at all times and that all domestic waste is properly containerized and disposed of.	Visual inspections and documentary proof provided.	Weekly inspection and report monthly	Contractor/ PMU/ DOE
9. Provide proper sanitation facilities at workers camps and at work site.	Visual inspections.	Weekly inspections and report quarterly.	Contractor/ PMU/DOE
10. Ensure appropriate equipment washing stations are established and used – and ensure that no motor vehicles, construction equipment, including concrete mouldings, are washed in waterways.	Visual inspections and laboratory testing of nearby water bodies.	Monitor weekly report quarterly	DOE /Contractor
11. Locate campsites away from waterways and provide amenities.	Visual inspections.	As required	Contractor/ PMU/DOE
12. Provide proper sanitation facilities at workers camps and at work site and service them weekly	Visual inspections. Laboratory testing of nearby water bodies.	Weekly inspections and report quarterly.	Contractor/ PMU/DOE
13. Conduct public awareness about the health and environmental hazards of illegal dumping.	Public Campaign In Place	Continuous	DOE
14. Increase enforcement of applicable legislation(s).	Enforcement of legislation. Rate of conviction.	Continuous	DOE
Illumination			
Activity: 1. Security Light and Working Light			
Impacts: 1. Compromising road safety, health, disrupting ecosystems and spoiling aesthetic environments			
1. Spotlight/security light should not be directed to the residential area but rather to be angled downwards. Keep floodlighting beam 70^{o} of vertical.	Work records log. Site inspections.	Ongoing Monitoring and report quarterly	Contractor/ PMU
2. Illumination of campsite and construction site must take into account the possible distraction glare might have on motorists. Receiver should not receive direct light.	Work records log. Site inspections.	Ongoing Monitoring and report quarterly	Contractor/ PMU

Illumination			
Mitigation Measure(s)	**Monitoring Indicator(s)**	**Monitoring and Reporting Frequency**	**Party(ies) responsible**
3. Lighting system should not flicker or cause stroboscopic effects.	Work records log. Site inspections.	Ongoing Monitoring and report quarterly	Contractor/ PMU
4. Night-time light sources must be directed away from conservation areas, naturally vegetated areas, as this may be the cause of ecological disturbance.	Work records log. Site inspections.	Ongoing Monitoring and report quarterly	Contractor/ PMU
Health and Safety			
Activity: 1. The Overall Safety of Workers			
Environmental Effects: 1. Road construction and upgrading poses potential hazards to workers			
1. Implement a management plan for safety of workers during the road construction which should include provision of temporary resting/dining and sanitation facilities, training the workers on safety measures, wearing of personal protective equipment such as long pants, work boots, hard hat, gloves, ear plugs and dust masks as may be necessary, and keeping the workers alert to possible dangers as well as avoidance to unnecessary risks.	Health and Safety Management Plan Implemented. Visual Inspection.	Throughout the duration of construction and upgrading of the PGH (Miles 8.5 to 24.5 Miles)	Contractor/ PMU/DOE

ECOSYSTEMS AND BIODIVERSITY			
Mitigation Measure(s)	**Monitoring Indicator(s)**	**Monitoring and Reporting Frequency**	**Party(ies) responsible**
Activity: 1. Road Footprint			
Impacts: 1. Ecosystem loss			
1. Maintain verge width at minimum (10ft) required to reduce habitat loss.	Work logs and site inspections.	Quarterly	Contractor/ PMU, DOE
2. Confine works to the exact footprint of the road wherever possible, avoid unnecessary construction vehicle turning sites, etc., and prevent physical damage to adjacent vegetation and soils.	Work logs and site inspections.	Quarterly	Contractor/ PMU, DOE
3. Rehabilitate and replant all verges on completion of works	Work logs and site inspections.	Quarterly	Contractor/ PMU, DOE
Impacts: 2. Loss of Ecosystem Connectivity			
1. Culverts/underpasses can be of significant value in helping maintain habitat connectivity for wildlife across roads, at a relatively low cost, reducing road kills. Culverts should be integrated into road design in key wildlife areas (Sections 2B and 1B at mile 11) to act as wildlife underpasses: at least 1m wide and 1m high, and designed to not hold water other than during storm drainage flow.	Work logs, report and site inspections.	On completion	Contractor/ PMU, DOE
2. Verge maintenance should be limited to the minimum width (10 ft) required by MOW and the Utilities right of way.	Work logs and site inspections.	Twice yearly	Contractor/ PMU, DOE

ECOSYSTEMS AND BIODIVERSITY

Mitigation Measure(s)	Monitoring Indicator(s)	Monitoring and Reporting Frequency	Party(ies) responsible
Impacts: 3.General Biodiversity/ Wildlife Population			
1. Confine works to the exact footprint of the road wherever possible, avoid unnecessary construction vehicle turning sites, etc., to prevent physical damage to adjacent vegetation and soils.	Work logs and site inspections.	Quarterly during works	Contractor/ PMU, DOE, FD,
2. Maintain verge width at minimum required to reduce habitat loss.	Work logs and site inspections.	Quarterly	Contractor/ PMU, DOE
3. Develop and enforce a fire-risk reduction policy to be followed by all work crew members.	Work logs and site inspections.	Quarterly during works	Contractor/ PMU, DOE, FD,
4. Rehabilitate all verges on completion of works	Work logs and site inspections.	Quarterly	Contractor/ PMU, DOE
5. If Mexico Creek Bridge is to be replaced, design replacement with flat and unobstructed base, to allow free movement of tapirs and other wildlife along the watercourse.	Design plans, Work logs and site inspections.	On completion	Contractor/ PMU, DOE, FD
6. When replacing culverts, whenever road elevation allows for it, ensure that new culverts are at least 1.5m in diameter (or height and width) to allow ready use as crossing points by wildlife in dry weather.	Design plans, Work logs and site inspections.	On completion	Contractor/ PMU, DOE
Activity: 2. Road Footprint			
Impacts: 1. To Yellow Head Parrot and Jabiru Stork			
1. Ensure that all clearance crew members are aware of the protected species status of the yellow-headed parrot, and require them to report any illegal harvesting, sale or transportation observed during their work period.	Work logs and site inspections.	Quarterly during works	Contractor/ PMU, FD
2. Develop and enforce a fire-risk reduction policy to be followed by all work crew members.	Work logs and site inspections.	Quarterly	Contractor/ PMU, DOE, FD
3. Ensure all work crew members adhere to the Wildlife Protection Act protecting nesting parrots of all species	Work logs and site inspections.	Quarterly during works	Contractor/ PMU, DOE, FD
4. Deter use of the Grace Bank road by work crew members for access to the River during jabiru nesting season.	Work logs and site inspections.	Quarterly during works	Contractor/ PMU, DOE
Impacts: 2. Road Kill			
1. Erect road speed limit and road curve signs to help deter speeding.	Road speed and curve signs	On completion	Contractor/ PMU-MOW,
2. Work with communities and NGOs to record wildlife road-kills and use data to determine whether there are hotspots that merit wildlife crossing signage	Consultation output report.	On completion	Contractor/ PMU, DOE, FD
3. Erect signage as indicated from Action c above.	Signs.	On completion	Contractor/ PMU, DOE, FD
4. Erect road speed limit and road curve signs to help deter speeding.	**Road speed and curve signs.**	**On completion**	Contractor/ PMU

ECOSYSTEMS AND BIODIVERSITY			
Mitigation Measure(s)	**Monitoring Indicator(s)**	**Monitoring and Reporting Frequency**	**Party(ies) responsible**
Activity: 3. Increased Edge Effect			
Impacts: 1. Loss of Ecosystem Connectivity			
1. Confine all construction activities to the precise footprint of the road, bridges, verges, and drainage ditches.	Work logs and site inspections.	Twice yearly	Contractor/ PMU, DOE
2. Maintain “soft” (vegetated) verges outside urban areas.	Work logs and site inspections.	Twice yearly	Contractor/ PMU, DOE
Activity: 4. Clearance of Waterways (Black Creek, Mussel Creek and Mexico Creek)			
Impacts: 1. Central American River Turtle (Hicatee), Howler Monkey, Tapir, and Antillean Manatee			
1. Ensure that annual re-clearance of waterways before hurricane season (Black Creek, Mexico Creek and Mussel Creek) is done manually, without heavy machinery.	Work logs and site inspections.	Quarterly	Contractor/ PMU, DOE
2. Ensure that all clearance crew members are aware of hicatee, howler monkey and yellow head parrots, protective legislation and require them to report any illegal harvesting or transportation observed during their work period	**Work logs and site inspections.**	**Quarterly during works**	Contractor/ PMU /BFD/ FD
Activity: 5. Re-clearance of Waterways			
Impacts: 1. Central American River Turtle (Hicatee), Howler Monkey, Tapir, Yellow-Headed Parrot and Antillean Manatee			
1. Prohibit the setting of fishing nets, or use of other means of turtle capture, by the clearance crew.	Work logs and site inspections.	Quarterly	Contractor/ PMU /BFD/FD
2. Leave creek bank vegetation (hicatee nesting cover) undisturbed.	Work logs and site inspections.	Quarterly during works	Contractor/ PMU /BFD/FD
3. Enforce a low-noise policy to be adhered to by the re-clearance work crews during creek clearance.	Work logs and site inspections.	Quarterly during works	Contractor/ PMU, DOE
4. When replacing culverts, whenever road elevation allows for it, ensure that new culverts are at least 1.5m in diameter (or height and width) to allow ready use as crossing points by tapir.	Design plans, Work logs and site inspections. Completion Report.	Report on completion	Contractor/ PMU, DOE, FD
5. Remove recovered debris from creek clearance (both natural and man-made) from the immediate vicinity.	**Work logs and site inspections.**	**Quarterly during works**	Contractor/ PMU, DOE
BFD = Belize Fisheries Department DOE = Department of Environment FD = Forest Department PMU = Project Management Unit Ministry of Works			

9.1.3 Environmental Monitoring Requirements

Monitoring is a supportive component to the aforementioned mitigation measures. An Environmental Monitoring Plan provides information necessary to ensure that the recommended mitigation measures set out in the design of the rehabilitated road works are implemented in accordance with the requirements of existing legislations and recommended mitigation measures. Therefore, monitoring is a supportive component to the aforementioned mitigation measures. Monitoring results are also used to determine the need for additional measures at an early stage to ensure that pollution or other related problems are discovered in time to prevent or repair adverse effects. In addition, compliance monitoring by Department of Environment (DOE) is also supported by a series of other environmental monitoring requirements using predetermined key indicators.

The objectives of conducting monitoring of the road rehabilitation impacts include the following:

- Provides information against which any short or long term environmental impacts of the Project can be determined;
- Provide an early indication should any of the environmental control measures or practices fail to achieve the acceptable standards;
- Monitor the performance of the Project and the effectiveness of mitigation measures;
- Provide Information that will enable more accurate prediction of impacts;
- Warn the Contractor of unanticipated adverse impacts to the environment;
- Provide information that can be used to monitor the performance and evaluate the effectiveness of the mitigation measures; and
- Ensure that all the respective targets and deadlines are met in an environmentally responsible manner.

9.1.4 Proposed Monitoring Program

The monitoring program has been developed not only in relation to satisfying the requirements of the ESIA process, but also as an objective of Ministry of Works (MOW) and Social Investment Fund (SIF) to ensure the proper implementation of the proposed road works. The parameters chosen for the monitoring program are those that have been identified primarily for the construction phase of the project since upon completion, the negative impacts during its operational phase are anticipated to be minimal, while having net positive environmental, social and economic benefits.

9.4.1.1 Objective of Water Quality Monitoring

The principal objective of this monitoring plan is to provide direction on water quality monitoring issues for the phases of project development, construction, and implementation. Other objectives also include the conservation of water, protect the quality of water resources, and preserve the ecosystems. Other key objectives are to:

- Implement the monitoring plan to monitor potential flood prone areas, impacted river and streams and drainage water as a result of construction activities.
- Analyze collected water samples using the Standard Methods for the Analysis of Water and Wastewater.

9.1.4.1.1 Sampling Sites

The project will entail both construction and post construction monitoring sites. During construction, monitoring will be generally undertaken upstream and downstream of the works. The sampling sites during post construction will be less than those of the construction phase, but more representatives of the identified impacts such as site runoffs on receiving waters. Sampling sites (see Table 9.2) include but are not limited to:

- Mexico Creek (2 points: PGH-WS 1 and PGH-WS2) during road construction/elevation activities near the approaches to the bridge and during the replacement of the bridge.
- Mussel Creek (PGH-WS3) during activities associated with the removal of debris and vegetation blockages.
- Black Creek (PGH-WS4) during activities associated with the removal of debris and vegetation blockages.

Table 9.2: Sample Sites Location and Coordinates.

SITE			Coordinates WGS84	
ID#	**Description Water Body**	**Way Point[1]**	**m E**	**m N**
1	Mexico Creek (Upstream)	PGH-WS1	351952	1952665
2	Mexico Creek (Downstream)	PGH-WS2	351938	1952566
3	Mussel Creek	PGH-WS3	351130	1951493
4	Black Creek	PGH-WS4	346931	1952883
[1]PGH-WS = Philip Goldson Highway Water Sample				

9.1.4.1.2 Sampling frequency

As the construction works have an impact on the receiving waters during times of site discharge, upstream and downstream samples should be taken as soon as practical following rainfall events. Rainfall events refer to times when runoff from the site is entering the receiving waters through on-site sedimentation controls such as silt-curtains or when sedimentation traps require maintenance discharge to restore their design capacity. Samples should be collected at the rate of:

a. Once quarterly (once every three months) during periods when rainfall results in any discharge from the site or when discharging from a point source such as controlled sedimentation basin discharges.

b. Once quarterly (once every three months) during times when there is no rainfall.

Post construction monitoring will be collected once quarterly (once every three months) for one year. If a number of results demonstrate that the site or parts of the site have stabilized, the sampling frequency and sampling locations may be reviewed and reduced or discontinued.

9.1.4.1.3 Monitoring Parameters

Construction monitoring samples will be analyzed for:

- pH
- Total suspended solids (TSS)
- Turbidity (where a correlation with TSS is sought and a portable probe is available)
- Oils and grease (visual assessment). If oils and grease are visually evident, a sample will be forwarded to the laboratory for analysis. Values should not exceed 10 mg/l.
- Total *Coliform* and *E. coli* analysis
- Possibly other parameters may be identified following construction activities.

(Note: pH and turbidity should be recorded in-situ with a portable probe and meter. Turbidity measurements may be substituted for TSS analysis provided a correlation has been established between the two parameters on a site-specific basis within the project).

9.1.4.1.4 Turbidity Measurements as a Trigger for Site Management

Turbidity measurements should be taken at all sampling sites during construction using either a portable turbidity meter or turbidity tube. A portable meter is preferred to a turbidity tube as the results obtained from using a turbidity tube may be limited by the variability of the eyesight of users and may not be highly accurate.

Turbidity measurements have the advantage of providing site management with immediate data, while TSS may take one week or more to be analyzed and reported. Where routine turbidity measurements show that a receiving water body is being negatively impacted, additional measurements can be taken with the probe to further determine the source.

Post-construction monitoring parameters will be the same as those used during the construction of the project. Individual parameters that may be added include Dissolved Oxygen and Temperature. Other parameters may be withdrawn where it is demonstrated that it is no longer a concern such as the control of erosion where re-vegetation has stabilized the soil.

9.1.4.1.5 Interpretation of Results

The monitoring program will incorporate a feedback loop to provide rapid dissemination of the results (visual, in-situ or laboratory) to the contractor to ensure problems are rectified as soon as possible. If repeated results demonstrate that the site or parts of the site have stabilised, upstream and downstream sampling parameters, frequencies, and locations will be reviewed in order to reduce or discontinue monitoring (see Table 9.3).

Table 9.3: WS Template with File Numbering System.

Date:								
FILE	**Sample Location**	**Dissolved Oxygen (mg/l)**	**pH (Units)**	**TSS (mg/l)**	**Turbidity (NTU)**	**Total Coliform (Count)**	**E. Coli (Count)**
Standards		**4 to 5**	**6.5 to 8.5**	**100**	**5**	**Drinking/Recreational Waters**	
						0/100	**0/100**
PGH-WS01	1						
PGH-WS02	2						
PGH-WS03	3						
PGH-WS04	4						

9.1.4.1.6 Reporting and Responding to Exceeded Criteria

Once the water quality criteria and/or targets are exceeded, a process for reporting and responding will be followed:

- Validation of result(s) showing exceeded criteria.
- Repeated or further monitoring.
- Investigation to determine cause and source of the exceeded criteria.
- Review of pollution controls and/or construction activities or procedures.
- Reporting to the Contractor.
- Reporting to the Department of the Environment.
- Documentation of all of the above.

9.1.4.2 Ambient Air and Noise Quality

This Ambient Air and Noise Quality Plan will monitor air and noise pollution generated as a result of the construction activities and post construction operation. The plan aims to address the control of fugitive and airborne dust emissions as well as vehicular exhausts emissions and related above normal noise generation. The sources of air and noise pollutants at the different phases of the road rehabilitation project are categorized as follows:

i) *Construction Phase*: Construction works include road surface removal, movement of vehicles, transportation of materials, camp erection, infrastructure provision and any other infrastructure activities. These activities contribute to increased noise levels. The major temporary air pollution is dust generated as a result of these construction works.

ii) Operational Phase: The major permanent sources of air pollutants are the vehicle emission from traffic on the roads. While noise pollution will be as a result of increased vehicular traffic and increased speed.

9.1.4.2.1 Objectives

The primary objective of this monitoring plan is to formulate a strategy for controlling, to the greatest extent practicable, fugitive or airborne dust emissions and exceeding levels of noise disturbances. This will be accomplished by identifying specific sources and activities that have the highest potential to produce or generate the disturbances. This plan describes the engineering controls necessary to minimize and control dust emissions from those sources and activities as well as the reduction of noise generated by the activities. As necessary, the scope of this plan will be revised to reflect changes in dust control strategy as site conditions or activities may change in the future.

As a precautionary and control measure for this project, the monitoring plan will be used as a standard operating procedure (SOP). This plan will be used:

- To eliminate origins of dust and excess noise from the project during construction activities;
- To identify the potential air and noise migration pathways;
- To monitor for dust, emission and noise produced by site activities; and
- To implement corrective actions as the need arises.

This plan is being prepared and submitted with the understanding that it can be modified to accommodate actual site conditions as they arise and in conjunction with all safety and health precautions.

9.1.4.2.2 Sampling Sites

The sampling sites for the proposed monitoring phase for ambient environmental quality will be limited to designated areas such as schools and urban areas during the road rehabilitation works. In summary, the sample sites include the following general area (see Table 9.4):

- Project sites along the different residential areas and school zones;
- Ladyville Urban Area; and
- At biological sensitive areas as identified in the impact assessment.

Table 9.4: Ambient Air and Noise Sample Locations.

SITE*			Coordinates WGS84	
#	Description	Sampling Point	m E	m N
1	Ladyville	NA1	363023	1940504
2	Lady of Our Way RC School	NA2	362258	1940654
3	Ladyville Evangelical School	NA3	360999	1941549
4	Tubal Trade and Vocational Institute	NA4	360294	1941674
5	Guadalupe RC School	NA5	354836	1949630
6	Pancotto Primary School	NA6	354776	354776
7	Sandhill Community Preschool	NA7	354786	1950412
8	Sandhill	NA9	353819	1951851
9	Mexico Creek Bridge	NA8	351945	1952617
***to be monitored when construction is being conducted on or near site.**				

9.1.4.2.3 Sampling Frequencies

The sampling frequency for these parameters will vary but it is recommended that a sample be taken at the peak hours of each working day to get a maximum variant. Thus, air and noise samples must be taken:

- Once per day, preferable during peak hours so maximum variance may be compared to early morning reading;
- Once per month at designated Point of Interest (POI).

9.1.4.2.4 Monitoring Parameters

Sample parameters for dust or air borne pollutants, vehicular emissions, and noise pollution include the following:

- *Air and dust pollutants* – Suspended Particulate Matter and Carbon Monoxide.
- *Noise Pollution* – limits are set according to the dBA Scale as described in the Pollutions Regulations Second Schedule (Regulation 42) and the World Health Organization guidelines, whichever is more stringent.

9.1.4.2.5 Interpretation of results

The monitoring program will incorporate a feedback loop to provide rapid dissemination of the results (visual, in-situ, or laboratory) to the contractor to ensure problems are rectified as soon as possible (see Table 9.5). If repeated results demonstrate that the site or parts of the site have stabilized, then the parameters will be reviewed in order to reduce or discontinue monitoring.

Table 9.5: Environmental Quality Template with File Numbering System.

Date:								
FILE	**Sample Location**	**SPM**	**SO_2**	**CO**	**NO_x**	**Noise levels dBA**		**Blank**
						Day	**Night**	
Industrial and Mixed Use		500	120	5000	120	70	70	
Residential and Rural		200	80	2000	80	55	45	
0001								
0002								
0003								
0004								
0005								
0006								

9.1.4.2.6 Reporting and responding to exceeded criteria

The program will include a process for reporting and responding to exceeding the limits set by the DOE's Pollution Regulation criteria (See Table 9.6) as follows:

Table 9.6: Regulation 6 – Concentration of Air Contaminants.

		SPM	CO
A	Industrial and Mixed Use	500	5000
B	Residential and Rural	200	2000
C	Sensitive	100	1000

9.2 Monitoring Cost

The monitoring will incur a cost to the project and therefore a budget allocation will be required. Environmental monitoring of the road rehabilitation will be done by assigned qualified personnel and with the assistance from the Department of the Environment. The project intends to attach a technician from the Department of the Environment to the project so he/she can be a part of the monitoring team. This capacity building measure should benefit the Department's role in identify the impacts, institute mitigation measures and devise a monitoring plan to verify its effects and make corrective actions. The costs presented below in Table 9.7, are all indicative, and will be refined at the start of the construction contract.

Table 9.7: Monitoring Plans.

Monitoring Plans	Indicative Costs ($)	Duration	Notes
Water Quality – transportation to sampling sites, collection and storage and analyzing all samples.	15,000	Pre and post construction (2 months)	Sample includes parameters and assigned personnel
Environmental Quality – monitoring of air and noise pollution.	25,000	Pre and post construction (2 months)	Costs include purchase of monitoring meter

9.3 General Reporting Requirements

In the general context of the monitoring plan, there must be established target goals and objectives in terms of monitoring the anticipated impacts. The results of these plans must be reported to the DOE as part of their requirement. Likewise, any adverse or potentially adverse impact must be reported immediately to the DOE and PMU as well as other regulatory agencies. Table 9.8 provides a template that could be used by the PMU/ DOE Officer assigned to the project to monitor compliance with the Environmental Compliance Plan (ECP) and ESMP.

Table 9.8: Monitor compliance with the ECP and ESMP.

Name of Person Filling Form:_______________				Date:__________	
Activity	**Environmental Effects**	**Mitigation Measure(s)**	**Monitoring Indicator(s)**	**Monitoring and Reporting Frequency**	**Party) responsible.**
List all activities in ESIA that received a "negative determination with conditions." ***Do not list any other activities.***	List main environmental effects that require mitigation	If mitigation measures are well-specified in the ECP quote directly from ECP If they are not well-specified in the ECP define more specifically here.	Specify indicators to (1) determine if mitigation is in place and (2) successful. For example, visual inspections for seepage around pit latrine; sedimentation at stream crossings, etc.)	For example: "monitor weekly, and report in quarterly reports. If XXX occurs, immediately inform project manager or DOE."	**If appropriate, *separately* specify the parties responsible for mitigation, for monitoring and for reporting.**
Signature of Person completing Form:_______________					

9.4 Social Management Plan

Based on the findings presented in D-2B-ESIA Report, the MOW commits to undertake a number of specific mitigation and management measures to ensure that the PGH Road Project (Miles 8.5 - 24.5) minimizes or avoids any negative impacts and maximizes potential positive social impacts.

The Social Management Plan (SMP) describes the overall management and monitoring of these mitigation measures. It specifies the responsibilities, timings, institutional structures, human resources, and estimated annual costs required to effectively implement the social management plan.

In tandem with adaptive management strategies, the SMP will need to be updated and adapted throughout the Road Project's lifecycle, as impacts change according to the Project development phases, social context changes and as Project milestones are attained. Recommendation is for the SMP to be formally reviewed and updated semi-annually throughout the life of the operations. The aim is to ensure that the social and economic environment, workers, Project stakeholders and PAPs do not suffer adverse impacts during the development and life cycle of the Project and enjoy access to derived social and economic benefits. The SMP contains: a breakdown of mitigation measures, key performance indicators, targets, responsibilities, estimated annual costs; key obligations of the lead construction contractor/s; and described responsibilities and mechanisms for implementation and monitoring of the SMP inclusive of: management and staffing structures; and means for monitoring and reporting on the SMP performance

9.4.1 Social Impact and Risk Management

The Government of Belize is committed to the protection of PAPs; to this end, and in tandem with the WB social safeguards, this section outlines management measures that have been developed in order to minimize or avoid negative Project impacts and maximize Project benefits.

Social Impact Management Measures: Includes specific mitigation and management measures for each impact identified in the SIA with a description of the social performance targets that MOW and its contractors will strive to meet, measured using specified Key Performance Indicators (KPIs);

Management of Social Risk: Social risks will be managed through mitigation and a Participatory Public Participation Process, inclusive of a Grievance Mechanism, and developing good relationships with stakeholders and PAPs;

Social Management Mechanisms: It is recommended that the MOW through its coordinating relationship with CRIP PMU implement the following key social management mechanisms: a Grievance Mechanism, to provide the structure for responding where the social impact mitigation measures are not functioning as envisaged, or when unanticipated social impacts (for which mitigation measures have not been developed) arise; the appointment of community liaison officers, one for each of the populated road sections [Section 1(A&B), Section 2 (A and B)] for the construction phase of the Road Project; and complemented by an established toll-free hotline to allow for road users to further report any potential grievances for possible resolution. These mechanisms are core to the effective management of social risks by ensuring strong relationships and open communications with Project stakeholders and PAPs.

9.4.1.1 Management of Social Mitigation Measures

Table 9.9 outlines the recommended management measures and targets for the social impacts identified and presented in the ESIA Report; this Table specifies the:

- Key Performance Indicator used to assess the extent to which an impact is effectively managed; these KPIs need to be reviewed and updated throughout the life of the Project;

- Target or the level of the KPI that the Project will commit to achieving; to this end close collaboration with local village councils (Ladyville, Lords Bank, Sandhill and Gardenia) is recommended;

- Mitigation and Management Measures to effectively address identified impacts and risks. While some management measures cannot be defined at this point, either because they will be the responsibility of Project contractors who have not yet been hired, or because the Project design is evolving. In these cases the management measures when defined will be adequate to meet the KPI target as specified;

- The party responsible for development and implementation of the relevant management measures for each impact, including both construction contractors and MOW team as relevant; and,

- The indicative Cost associated with effective implementation of the mitigation and management measures.

Table 9.9: Summary Impacts, Mitigation, KPI, Targets, Responsibility, and Costs.

SMP related costs is BZ$1,628,000 inclusive of conservative estimate of BZ$1 M for possible resettlement compensation and BZ$0.5 M for procurement and installation of CCTVs in 3 school zones.

Impact Category	Impact	KPI	Target	MOV	Responsibility	Mitigation/ Management Measure	Indicative Cost: '000
Community Governance, Cohesion and Organization	**Community Governance and Participation:** The Road Project stands to positively impact on community governance by contributing to improved public confidence among and between local and central level government and community residents, especially in communities like Sandhill where political polarization and exclusion due to partisan politics are pronounced. Early engagement and participation of village councils and residents of communities within the Study Area has contributed to engendering a process of inclusion and participation;. Village councils and for the most part residents have expressed appreciation in being consulted on the proposed road rehabilitation; notwithstanding, a small number of residents have been hostile and out rightly refused to participate in the early engagement and consultations activities, particularly in the Ladyville Area. Outside the duly elected village councils, organized religious and political groupings and other community organization are not common. The community of Gardenia has shown past evidence of an organized women's group; however, it is no longer active. The right of community residents to know, participate and potentially influence the Road Project decision-making processes and protect their community interests is contributing positively; this positive impact is highly correlated with the extent, quality and effectiveness of the on-going community engagement and consultation process. With the exception of Sandhill Village, the area representative and central government are easily accessible and supportive. Notwithstanding,	Number of consultation meetings conducted by road project lifecycle Participation rate of stakeholders in consultation meetings by road section PAPs reported level of satisfaction with village council representation with the Road Project consultations	Design: 2 Construction: 1 Operation: 1 5% participation rate in community-level meetings[10] 50% of PAPs report satisfaction with village councils' representation	Meeting attendance sheets PGH performance survey	Community Relations Focal Point and 2 CLOs (1 per Road Section): MOW Social/M&E Officer: BSIF CRIP PMU	Continued consultation by MOW to ensure that it works with the village councils and contractors who are open to the hiring of socially marginalized groups (women and youth) for broader based Project support; Explore service contracts for maintaining the rehabilitated PGH MILES 8.5 - 24.5 with the village councils across Road Sections (e.g. drainage cleaning, overgrown clearing, road side garbage pick-up, etc).to strengthen ties between local and central government and demonstrate tangible commitments with respect to ensuring the hiring of locals with special emphasis on women and youth Implement a toll-free hotline to facilitate ongoing communications between road users and MOW/CRIP PMU Additionally, explore opportunities for enforcement of traffic laws with shared benefits from fines accruing to village councils and central government	**CRFP: 36 k p.a.** **CLOs: 12 k; 6k/CLO** **Hotline: 2k**

[10] Given the low levels of community turnout at public meetings despite use of direct and mass media communications

	decision making is highly centralized and usually non-participatory and non-inclusive; where participation/inclusion is sought, it is traditionally of a partisan political and transactional nature. Active community participation and access to decision making is not the norm in community projects which are usually top down in their approach. The general exception in the affected communities is in relation to SIF projects which are underpinned by community inputs via participatory appraisal methodology.						
Services and Community Resources	**Recreation, Parks and Playground:** The communities of Ladyville, Lords Bank and Sandhill reflect better recreational resources compared to Gardenia and Biscayne. To this end, these communities engage in far more intra- and inter-community sporting activities. It is expected that the proposed Road Project will positively impact on these recreational activities by attracting increased visitors from Belize City and neighbouring communities given the reduced travelling time and improved road safety.	Inter- and intra-community participation in sporting activities	Medium-high level of participation	Observations Key informant interviews	Community Relations Focal Point and 2 CLOs (1 per Road Section): MOW Social/M&E Officer: BSIF CRIP PMU	-	-
	Water and Sewage Infrastructure: BWSL water mains across the road sections are located within the road reserve; as such these are completely exposed. To this end, planned service interruptions may be unavoidable and access to water services may be negatively impacted during the construction phase. Outside of the planned water interruptions, sewage disposal (flushed toilets to septic) are not anticipated to be impacted by the Project across the Road Sections.	Number of HH reporting water interruptions Average length of time water supply is interrupted	Water supply is uninterrupted by the Road Project	Grievance database Toll free hotline reports	MOW / CRIP PMU	MOW is committed to using appropriate construction mitigation measures as earlier noted and due diligence to ensure that people will not be negatively impacted. Thus the location/re-location of the electric poles/lines and water lines will be effectively coordinated with BWS and BEL. Additionally, as a key component of the wider communications strategy PAPs will de duly informed of any planned outages well ahead of time.	**Cost of protection/relocation of water/electric lines borne by the Project (GOB)**
	Electricity Infrastructure In many instances, electric poles fall within the road reserve across the road sections. Planned service interruptions may be unavoidable and access to electricity services may be negatively impacted during the construction phase.	Number of HH who report electricity interruptions Average length of time electricity supply is interrupted	Electricity supply is uninterrupted by the Road Project				
	Public Transport and Road Use: Construction vehicles may put pressure on and negatively impact the public transport and road system across the Project Area; access routes for pedestrians, cars,	Grievances related to traffic/transport [lateness to school/work]	No legitimate unresolved grievances related to	Grievance database	MOW / CRIP PMU	Schedule road works outside of peak hours; utilize good practice related to traffic management; establish adequate diversions; and ensure continuous and effective	-

	buses, and trucks could be impeded by construction vehicles thereby increasing travel time for school, work, access to services and business. Additionally, existing bus stops fall within the existing road reserve and would need to be demolished and rebuilt with proper bus pull-offs. In the operation phase however, positive benefits are expected with the proposed road upgrade, inclusive of modern road design and dressings.	Number of bus stops restored	traffic/transport 100% of bus stops restored with appropriate lay-byes	Site inspection		communications to road users	
	Education/Infrastructure and Service: Education infrastructure and service could be either positively or negatively impacted by the Road Project. With the upgrade of the road sections, comes improved road safety for pedestrians with special attention to school children given the proximity of the existing road to schools in the communities of Ladyville, Sandhill, and Biscayne; with modern design and strict safety standards and enforcement, the road project is expected to positively impact on school safety. Additionally, dust and noise from construction and increased traffic flow from transportation of materials could adversely impact on educational services along the road sections.	Grievances related to construction impacts on schools along the ROW [noise, dust…] Proportion of school children/teachers/ parents who report safer road conditions	No legitimate unresolved grievances related to Project impact on schools along ROW 95% of PAPs reporting safer road conditions for pedestrians	Grievance database Performance monitoring survey Toll-free hotline reports	MOW / CRIP PMU Social/M&E Officer BSIF CRIP PMU	In general, adherence to standard road safety measures (speed reducers, pedestrian crossings, signage, etc.) across the road sections Special attention to school zones with added traffic enforcement measures explored, inter alia the use of CCTV and automated ticket system; revenue generated can be shared 3-ways: central government-village council-system maintenance Once introduced, CCTV can also serve other important functions such as traffic counts and improved child safety/protection. **Adopt a zero tolerance to speeding in school zones.** Regular spraying of water at least twice a day in high-traffic and/or high population density areas, inclusive of school zones by water bowsers	**CCTV: 500k (3/4 areas)**
	Health Infrastructure and Service: Except for the communities of Ladyville and Lord's Bank, who now share an improved health polyclinic, limited health infrastructure exists across the remaining communities. Given that many residents seek health services from Belize City, it is anticipated that the Road Project may adversely impact on this service due to increased travelling time during road construction; in the long term, however it is expected to positively impact given reduced travelling time and improved road safety.	Grievances related to construction impacts on road users travelling for medical purposes along the ROW [noise, dust…]	< 2% of all reported cases	Grievance database	MOW/ CRIP PMU	Schedule road works outside of peak hours; utilize good practice related to traffic management; establish adequate diversions; and ensure continuous and effective communications to road users	**Contract clause**
	Citizen Security and Crime: Outside of Ladyville Village, police presence and substations/precincts/ outposts are limited. Communities are generally	Police response time	30% reduction in overall Police response time	BPD Admin reports	MOW-BPD	-	-

	described as being safe with low levels of reported criminal activity; the relative exception being Ladyville with higher levels of reported homicides, domestic violence, and burglaries. It is expected that the road project will positively impact on the situation of crime and citizen security given increased police response time for communities neighbouring to Ladyville. On the flip side, the improved road conditions could also negatively impact due to increased presence of and reduced travelling time for the criminal elements.		along the ROW	Grievance database			
Health	**Health problems related to pollution:** The Road Project stands to positively impact pollution related health problems in the long term due to reduced dust; however, it may negatively impact during the construction phase.	Air emissions Health impacts resulting from noise or dust	Compliance with air emission standards No health impacts resulting from construction pollution	Environmental monitoring Grievance Database; MOH administrative data (respiratory illnesses)	MOW-DOE MOW-MOH	During the construction phase, a rigorous health and safety plan will be implemented to ensure excavation and construction activities minimise dust and noise-related pollution for the workforce, neighbouring communities and schools. Mitigation Measures will be clearly communicated to the PAPs to reduce stress caused by uncertainty.	**Contract clause** **Training: 5k** **Communication/Traffic Safety Campaign:40k**
	Communicable diseases: Influx of external labour force for the road project may increase exposure to communicable diseases, viz. STI/HIV.	% of workers with comprehensive knowledge of HIV % of workers aware of health and safety plan	85% of workers with comprehensive knowledge of HIV 100% of workers aware of health and safety plan	Admin data: Training report	MOW-MHD	The MOW through the PMU and its contractors with support from the Ministry of Human Development are required to implement HIV/AIDS awareness, prevention and control activities aimed at construction workers and the communities in the Project Area in line with the Environmental and Social Management Plan. Additionally good hygiene and health practices in line with the overall health and safety plan are to be observed	
	Injury: Construction, transport and operations could expose workers, residents, and other road users to increased RTAs and injuries.	Number of road users injured as a result of Project activities Number of RTAs during construction phase	No grievances/claims in relation to injuries % of RTAs within Road Section < 5%	Police/MOH Administrative reports	MOW-BPD/MOH	Implement sound traffic control measures to limit the risk of construction, operational and transport accidents which could endanger the health of community members; Conduct a road safety campaign to reduce the risk of traffic accidents for community members, particularly important for children;	
	Occupational Health: The Road Project may					MOW to require contractors to adopt strict	

	positively or negatively impact on the occupational health of workers/road users. By contractors adhering to OSH standards, the occupational health of workers, residents, and road users can be positively impacted via a culture of improved road safety practices. However, where these standards are not enforced/complied with, significant negative impact can be experienced inclusive of serious injury and/or loss of life.					construction and operation practices with best technology and health and safety training to ensure the safety of its workers in line with the OSH Bill. MOW to develop and implement a Traffic Safety Monitoring Plan to ensure lives are protected first and foremost and to respond appropriately to any traffic related incident/accident. To this end, they will: Carryout a safety checklist of all safety equipment; Assess the daily placement of all traffic safety equipment; Manage safely the passage of traffic within the work zones; and Notify the general public on detours and alternate routes	
Social and Demographic Characteristics	**Population: Structure and In-migration:** No impact on the population structure is projected in the short-term; however, job-seeking in-migration may negatively impact social and cultural aspects of communities due to differences in lifestyles particularly for communities beyond Ladyville. **Social Cohesion** Social cohesion within and among communities along the road sections could be adversely impacted by differential access to Project opportunities and influx of Project workers. **Poverty/vulnerability and Social exclusion:** Project costs and benefits could either serve to reduce or increase the vulnerability of specific groups of affected persons(women, youth, children) in the short-term thus having either a positive or negative impact dependent on how these costs and benefits are borne/accrued/ distributed. Special attention to equity and special employment quotas for women and youth are strongly recommended. MOW to require contractors to enforce zero tolerance to child labour. **Child and Adult Protection:** The Project has the potential to negatively impact communities as it	% of workers hired from local PAPs communities Number of grievances about workers' conduct Number of sexual exploitation/harassment cases reported, investigated and substantiated Number of child labour cases	40% of labour force sourced locally < 5% of all reported grievances relate to workers' conduct 100% of reported cases investigated Zero cases	Admin records: contractors HR files/SSB Grievance database Grievance database/BPD-WD admin reports Admin records: Labour Department	MOW/PMU Social/M&E Officer Village Councils MOW/PMU-MHD MOW/PMU-LD	MOW to require contractors to develop policies for workers induction and a socio-culturally appropriate code of conduct for interacting in communities inclusive of training on gender related issues inclusive of sexual harassment of adult females, sexual exploitation of adolescent girls and HIV and AIDS training; the latter could be arranged through the Ministry of Human Development, Women's Department/ independent social worker Source local labour force insofar as requisite skills allow with special quota for women to balance the population structure imbalance. Additionally conduct training for workers and the communities on mandatory child abuse reporting law Adopt and enforce zero tolerance to child labour practices	**2k: Training for workers/ contractors/ communities** **Contract clauses**

	relates to child labour, sexual exploitation of adolescent girls and sexual harassment of women by a usually predominant male workforce						
Cultural Heritage	**Archaeological sites/mounds/sites of interests:** No sites were readily identified via the Archaeological Assessment within the road corridor; to this end, the Project is not expected to impact on any known sites; however, all necessary mitigation measures will be taken during the construction phase to remove the potential for any negative impact on unknown sites. Additionally, the Road Project has the potential to positively impact on tourism (Mayan sites and protected areas in neighbouring communities, Burrell Boom, Crooked Tree, and Rockstone Pond) through reduced travelling time and improved access for tourists/travellers resulting in increased opportunities for livelihoods and overall added economic benefits/development of rural Belize District.	Number of grievances about destruction of cultural heritage	Zero grievances related to destruction of cultural heritage	Site visits Grievance database	MOW/PMU Social/M&E Officer NICH	The proposed road works will be limited to the existing corridor; to avoid potential adverse impacts on any unknown archaeological remains, it is recommended that an archaeologist undertake further investigate work prior to any clearances/excavation of test pits along the route. Should the investigation uncover substantial archaeological deposits a more detailed investigation would be required. It is recommended that such work is undertaken in close consultation with the Department of Archaeology.	-
	Cemeteries: Cemeteries managed by the respective village councils are outside the immediate zone of impact of the road project; to this end, the **proposed road project is not expected to impact on existing cemeteries.**	-	-	-		-	-
	Art Center: A small art centre, 'Sandhill Art Center', is operated just on the outskirts of the Village (Mile 19 ¼) and given its location within/in close proximity to the road reserve may be adversely impacted by the road project. To this end, demolition, temporary relocation, and reconstruction will be necessary to preserve the supported activities (details to be defined in the RAP report).	Preservation of Art Center facility	Art Center facility restored to its prior state or better	Site visit	MOW/PMU-Sandhill Village Council	Provide temporary relocated structure and reconstruct the Art Center (with pre-planning, relocation/reconstruction can precede actual road construction works in Sandhill to minimize disruption to livelihood and artistic expression)	**15k**
Involuntary Resettlement [Physical and Economic]	**Temporary/Permanent Land Take and Loss of Livelihood:** While the footprint of the proposed roadway is not anticipated to significantly diverge, horizontal alignments and construction of roundabouts in limited instances and as proposed in the feasibility study (conceptual designs) may be necessary and will affect existing property lines. Temporary land take may also occur where land will be acquired for contractor's camps, gravel pits	Number of grievances about compensation for land take and loss of livelihood % of affected persons reporting satisfaction with level of	No unresolved grievances related to compensation for land take/loss of livelihood 98% of affected persons reporting	Grievance database Site visits	MOW/PMU Social/M&E Officer	Constant communication and due lead time will be given to vendors with support for relocation in the interim; where private land take is absolutely unavoidable, market-value compensation to owners will be employed after due consultation process managed by the MOW and as defined and agreed to in the RAP.	**Exact value is unknown at this point; based on the final road design and RAP a more definitive value will be determined. Initial estimates are: 1,000k**

	and hard stone quarries. Generally, however upgrading of the road is expected to cause minimal adverse impact since the Project is designed in such a way that minimal land take will be required and affected home/land owners will be minimized. Additionally, and particularly during the construction phase changes to lifestyles and livelihood activities for a small number of roadside vendors who operate within the roadway reserve will occur as specified in the ESBA while residents will also be affected by construction activities including disturbance and increased pressure on resources and services. Detailed descriptions of impacted persons and properties, preliminary consultations and recommended actions to be detailed in RAP report.	compensation and process	satisfaction with compensation/ process			Additionally, consideration to loss of livelihoods during the construction phase will be explored in line with the WB safeguards and based on assessed levels of income..	
Economic Environment	**Costs of Goods and Services and SE Development:** It is not anticipated that the influx of Project workers will impact the cost of basic goods and services (inflation); the Project is however, expected to positively impact the socio-economic development and wider economic development of communities along the road sections in the medium to long-term through improved access to markets, safety and security and increased tourism.	-	-	-		-	-
Employment, Livelihoods and Income Generation Activities	**Employment and Skills:** Employment is a potential positive impact of the Project, directly through employment on the Project and indirectly through livelihoods. Poor governance practices relating to sourcing of labour and lack of/limited skills however may pose challenges to job access which could be a negative impact. **Skills** Project employment and training could positively impact the local skills base, by enhancing/diversifying skills base of women and youth.	Number of grievances about hiring practices % of workers hired from local PAPs communities Number of grievance about impact on livelihoods Number of grievances of child labour practices	No unresolved grievances related to hiring practices	Grievance database Site visits	MOW/PMU-Social/M&E Officer-Village Councils	The MOW and contractors will work actively to promote local access to Project employment in both the construction and the operations phases. To do this MOW and contractors will apply transparent and fair employment policies and work with local village councils to source local labour	**Contract clause**
	Development of Business and informal livelihood	Number of grievances	<5% of all	Grievance	MOW/PMU-	Schedule road works outside of peak hours;	-

	activities It is anticipated that the Project will positively impact on potential business development and livelihood activities in the medium to long term given ease of access and reduced travelling time; however in the short term these may be adversely affected due to road construction activities.	related to loss of livelihoods during construction phase	reported grievances relate to loss of livelihood	database Site visits	MHD	utilize good practice related to traffic management; apply dust suppression measures, establish adequate diversions; and ensure continuous and effective communications to road users	
Social Risk Management: Grievance Mechanism	The grievance mechanism is key to effectively track and assess the performance of the overall management of social impacts	Grievance mechanism and database designed and implemented	Date of establishment of database	Community sensitization on grievance mechanism Database reports	MOW/PMU Social/M&E Officer	Grievance Mechanism	**10k**

9.4.1.2 Management of Social Risk

As discussed in the ESIA Report, the Project faces potential social risks related to its socio-economic and political context. Social risk is also influenced by the fact that the types of consultation and application of social standards applied by the Project, in accordance with best practice, are relatively new. MOW's/PMU's social risk strategy ensures that social management activities undertaken are designed and implemented to actively reduce these associated risks. The following activities will make important contributions to social risk management.

PPP Activities: The Public Participation Process (PPP) outlines MOW's/PMU's strategy for stakeholder engagement. The PPP is a 'live' document that outlines how MOW communicates with the wide range of stakeholders and PAPs and incorporates the Grievance Mechanism for PAPs. The PPP therefore plays an essential role in reducing social risk by building relationships with stakeholders and PAPs, counteracting the spread of misinformation about the Project and ensuring that stakeholders have the means to communicate their legitimate concerns to MOW/PMU and receive responses and fair resolution as appropriate. MOW's/PMU's Grievance Mechanism, and the work of the recommended community liaison officers (CLOs) as elaborated on below, also serve as an early warning system, picking up on any relevant community discontent quickly to ensure it can be appropriately channelled and resolved by MOW/PMU and other associated agencies before it gives rise to social conflict or resentment against the Project.

Social Impact Management: The social impact mitigation management measures identified will reduce social risks by ensuring that negative Project impacts are avoided or effectively mitigated, and that Project benefits are shared equitably. This will contribute to PAPs having a positive perception of the Project, thereby reducing the associated social risk. This is of particular importance as it relates to direct economic benefit through sourcing of local labour with a focus on women and youth.

Socio-economic Baseline Change Monitoring: It is further recommended that socio-economic monitoring be on-going for the life of the Project, with periodic monitoring of the Project social context and social performance with informal assessment through the PPP and grievance processes on a rolling basis and formal monitoring Baseline Surveys at the mid- and end-points of the Road Project Cycle supported via the BSIF CRIP PMU SO/M&E Officer, at an estimated cost of BZ $24,000.

9.4.1.3 Social Management Mechanisms and Organizational Capacity

Implementation of the SMP is the direct responsibility of the MOW; however, it is understood that the MOW works through project contractors and other key government stakeholders and support from the BSIF CRIP PMU. To this end, it is of key importance that the MOW and the associated agencies responsible to implement the SMP meet with the requisite resources and capacity to do so.

Key associated organizations responsible for ensuring the successful implementation of the SMP are the: Department of the Environment; Women and Family Support Department; Lands Department; Labour Department; and the Ministry of Local Government.

It is the recommendation, that the Ministry of Local Government, through the local village councils of PAPs' communities be consulted and offer guidance in decisions with respect to sourcing local employment, strategic placements of bus stops, pedestrian crossings, sidewalks as well as exploring opportunities for road maintenance via service contracts during operations for added ownership, employment opportunities and greater cohesion between local and central government.

It is further recommended that the MOW/PMU establishes a Community Relations Focal Point (CRFP), at an estimated cost of BZ$36,000 p.a. within the PMU and contracts for the life of the Project, 3 part-time Community Liaison Officers, at a cost of BZ$18,000 per annum, dedicated to conveying information about the Project, implementing the SIA Mitigation Measures and meeting the Key Performance targets of the SMP and PPP. The CRFP will manage the Grievance Mechanism, including establishment and management of an online Grievance Database, to be developed at an estimated cost of BZ$10,000. The CRFP will also ensure that the Grievance Mechanism is functioning effectively via timely resolution of all lodged complaints within pre-established time frames; that there is a mechanism for applying lessons learned and that feedback to stakeholders is actually delivered. Additionally, the CRFP and the CLOs will coordinate and deliver training to PAPs on the application of the Grievance Mechanism at an estimated cost of BZ$3,000.

Additionally, and taking advantage of the level of ICT penetration across the PAPs' communities, it is further recommended that to complement the above mechanisms that MOW establish a toll-free hotline, managed by the CRFP, to further facilitate the reporting of any potential grievances by road users. While this is a recommendation for the life of the road project, it is a measure that could serve the MOW well beyond the project to facilitate reporting of issues by road users nationally.

9.5 MOW's/PMU's Grievance Mechanism

A grievance can be defined as an actual or perceived problem giving reason for complaint; in line with international standards, development projects should provide for a grievance mechanism to address concerns promptly, using an understandable and transparent process that is culturally appropriate and readily accessible to the affected communities, and at no cost and without retribution.

MOW/PMU is proactively seeking to prevent grievances through effective management and mitigation of the identified Project impacts and through pre-emptive community liaison activities designed to anticipate and address potential issues before they actually become a grievance.

Notwithstanding, the Grievance Mechanism is the official process by which people affected by the Project can bring their comments, concerns and complaints to the CLOs and the MOW management team. The Grievance Mechanism specifies: the Purpose; Scope and Target Group; Procedure; Management Structure and Tracking; and Monitoring and Reporting, the overall process flow is as outlined in Figure 9.1.

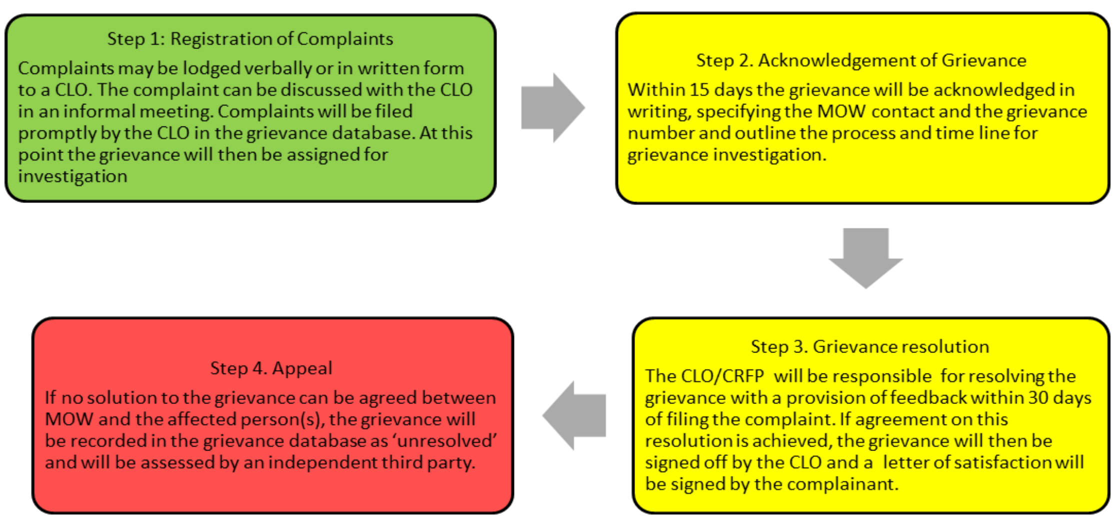


Figure 9.1: Grievance Mechanism Process Flow.

Management and Tracking of Grievances: The roll out of the Grievance Mechanism to community members will be the responsibility of the CRFP/CLO; explanations of the process to members of the various communities will be led by the CLOs.

Specific issues to be addressed during testing and subsequent roll out of the mechanism are:

- The Grievance Mechanism is accessible to PAPs, with special emphasis on those with limited levels of formal education;
- The Grievance Mechanism is publicized using culturally relevant and inclusive media;
- The Grievance Mechanism is accessible for local, national and international stakeholders (e.g. tourists);
- Community members are aware that they can use the Grievance Mechanism without retribution; and that grievances can be lodged without danger of retribution in practice, given that some Project affected stakeholders are reliant on informal livelihoods, and that some grievances may be lodged by workers against contractors who are their employers.

A Grievance Database System will be set up by the CSFP/CLO before the start of construction. This database will be designed so as to make it easily possible to track individual grievances (case management), giving each grievance a unique ID number (UIDN), trigger deadlines for progress on grievance communications and resolution as specified in the grievance process. The Grievance Database should specify where grievances have been resolved and a statement of satisfaction has been signed by the complainant. Where it has not been possible to resolve grievances to the satisfaction of both parties, this should be specified in the database, and unresolved grievances should be assessed during third party monitoring.

Monitoring and Reporting of Grievances: The implementation of the Grievance Mechanism is subject to third party monitoring (e.g. DOE, Ministry of Human Development, HD, World Bank …) to ensure that MOW/BSIF is performing effectively in its commitments to resolving community grievances. Third party monitors of the Grievance Mechanism will be provided with access to the Grievance database to audit performance. MOW through the CRFP/CLO will report on performance in closing out grievances (i.e. the number of grievances resolved within agreed time frames) as part of a monthly/annual public report. A Grievance Mechanism Leaflet for MOW is presented in Box 9.1; as well as a recommended Grievance Form, Table 9.10.

SAMPLE INFORMATION ON MOW'S GIREVANCE PROCESS

The Government of Belize through the Ministry of Works (MOW) and with loan facili9ty from the WB is proposing to rehabilitate the Phillip Goldson highway, Miles 8.5 – 24.5. To this end, and is normally associated with road projects of this nature, the MOW is implementing a Grievance Mechanism to ensure that anyone with a complaint about the Project can communicate it to the MOW and receive feedback on how their concern/complaint is being addressed.

WHAT KINDS OF GRIEVANCES CAN I RAISE?

Anyone, including both community members and staff of contractors or contractors themselves can raise a grievance with MOW if they believe that the Project is having a negative effect on them/their community, the environment or their quality of life. Examples of grievance could include, but are not limited to:

- ✓ Concerns about the environmental impact of the Project;
- ✓ Project impacts on quality of life, such as traffic problems, dust and noise;
- ✓ Project impacts on livelihood and employment activities;
- ✓ Health and safety problems related to the Project;
- ✓ Failure to comply with standards or legal obligations;
- ✓ Improper behaviour by staff;
- ✓ Financial malpractice, impropriety or fraud

MOW through its PEU will investigate all grievances that are submitted.

HOW TO REPORT A GRIEVANCE?

MOW has a number of ways through which to receive your complaint; you can:

- ✓ Complete the hard copy Grievance Form available from your CLO and send it to the address on the form or drop off at any MOW Office;
- ✓ Contact your Community Liaison Officer (CLO) in person/via phone to lodge a verbal grievance; the CLO will then complete a grievance form and submit to ensure your grievance cab be formally tracked;
- ✓ Communicate a grievance through the MOW website, online form; OR
- ✓ Use the toll-free hotline, 0-800-MYVOICE, to be provided for this purpose

FOLLOW-UP (Case Management)

Unless the CLO is able to deal with (resolve) your potential grievance immediately, MOW will go through the following steps to deal with it:

When MOW is in receipt of the grievance form or are notified verbally of the grievance, a member of staff will be assigned responsibility to investigate;

MOW will acknowledge the grievance by letter (post/CLO delivered) within 15 days of receiving the grievance or by e-mail of appropriate. This letter will identify your MOW contact and provide a reference number for your grievance.

MOW will then investigate the grievance and may need to contact you further. When MOW has completed its investigation you will be contacted with the findings and proposed resolution within 30 days of receipt of the grievance.

If you are satisfied with the investigation and the proposed resolution, MOW will ask you to sign a statement to this effect. If you are unsatisfied, MOW will discuss with you other possible options for dealing with the grievance and attempt to arrive at an acceptable resolution. If unable to arrive at an acceptable resolution, the grievance will be further managed by an independent 3rd party to be determined.

CONFIDENTIALITY AND ANONYMITY

If you request of MOW to keep your identity confidential in relation to your grievance, MOW will ensure that your name and details are known only to the grievance investigator/s and are not shared with other MOW employees/management, contractors, or people or organizations outside of MOW. If it is not possible for MOW to resolve the grievance without revealing your identity, MOW will contact you to ask how you prefer to address the situation. If you wish to raise a grievance anonymously, you may do so and MOW is obligated to still investigate the grievance. However, in this case MOW will not be able to make contact with you to discuss the results of the investigation/proposed resolution/mitigation measures.

Box 9.1: MOW Grievance Mechanism Information Leaflet.

Table 9.10: Sample MOW Grievance Form.

Contact Information						
Full Name:				○	○	
	(first)		(last)	Male	Female	
Address:						
Phone:						
e-mail:						
Road Section:	RS I-A	RS I-B	RS 2-A	RS 2-B	Other:	
Village/Community:						
Complainant Category:	Resident	Local Business	Village Chairperson	Councillor	NGO/CBO	
	Contractor	Contractor Employee	Other:			
If with an Agency/ Organization						
	Name of Agency				Position with Agency	
Brief Description of Grievance (when relevant, please provide specific names, dates and locations of incidents):						
Please note any recommendation for resolving the grievance?						
Signature			Date			

9.6 Consolidated Environmental and Social Management Plan

The sub-section summarizes, the key environmental and social mitigation and management measures for the Road rehabilitation Road Project across the following major requirements: General Construction; Drains and Culverts Construction; Excavation and Burrow Pit; Material Storage and Handling; Workers Camp; Ecological; Archaeological; Vegetation Removal and Re-vegetation; Traffic Management; Utilities Management; Community and Worker Welfare, Safety and Health; Mexico Creek Bridge Construction and Highway Construction Requirements.

9.6.1 General Construction Requirements

- Use of concrete pavement as finished surface in depressed areas that are subject to inundation and where elevating the level of the road proves impractical.
- Bridge approaches are recommended to have a minimum approach straight of 20m.
- Ensure that construction and support equipment have adequate and functional noise abatement devices to keep the noise level within acceptable construction noise standards.
- Road cuts are to be provided with slopes that will ensure its stability and not be subjected to erosion which could block drainage structures and the road.
- Adequate facilities for the collection and treatment of waste water; storage and disposal of solid waste are to be provided.
- Dump trucks to be equipped with devices to prevent material spillage.
- Adequate location of asphalt plant with storage place for raw and surplus materials; provisions for minimal discharge of fumes and dust
- Establish and adhere to construction timetables that minimize disruption to the normal activities of the construction area.
- Coordinate truck and other construction activity to minimize noise, traffic disruption, and dust.
- Develop and implement appropriate human health and worker safety measures during construction.
- Post construction timetables and traffic diversion schedules at the project site.
- Where significant environmental impacts may occur, document and photograph pre-construction and post-construction conditions.
- Backfill, level, and/or restore burrow pits and quarries before abandonment unless alternative uses for those sites are planned. Where areas are levelled spread topsoil on top.
- Control runoff into burrow pits.
- Provide proper, temporary sanitation at the construction site.
- Recover and replant topsoil and plants as practicable.

- Set protocols for vehicle maintenance to control contamination by grease, oil, and fuels.
- Install temporary erosion control and sediment retention measures (check dams and silt curtains) when permanent ones either are not feasible or are delayed.
- Avoid pollution of waterways with stockpiled construction materials.
- Cover stockpiled construction materials, as practicable.
- Place solvents, lubricants, oils, and other semi-hazardous and hazardous liquids over a lined area with appropriate secondary containment in order to contain spillage. Test the integrity of bulk storage tanks and drums, and secure valves on oil and fuel supplies.
- Build appropriate containment structures around bulk storage tanks and materials stores to prevent spillage entering watercourses.
- Handle, store, use, and process branded materials in accordance with manufacturer's instructions and recommendations.
- Take waste materials to appropriate, designated local disposal areas.
- Minimize burning of waste materials.
- Employ techniques to minimize dust and vapour emissions as practicable (e.g., road speed limits, air extraction equipment, scaffolding covers, road spray).
- Build sedimentation ponds, silt traps or other separators for silt-laden material prior to allowing significant outflow into watercourses.
- Build collection channels leading to oil and/or silt traps, particularly around areas used for vehicle washing or fuelling.
- Seal or remove abandoned drains to minimize water contamination.
- Segregate waste, which can be salvaged, re-used, or recycled.
- Introduce measures to control and minimize the volume of waste on site.
- Keep worksite free of litter
- Employ sensitive strategies with regard to trees, watercourses, plant or animal species or habitats, and important historical and archaeological features.
- As practicable, landscape construction sites in a way that is appropriate to local conditions.
- Minimize the disturbance of, and reduce the spread of ground contaminants.
- Do not build structures in sensitive areas such as wetlands.

- Provide for the safe disposal of grey water from bathing and washing.
- Erect noise and dust barriers near schools and sensitive areas.

9.6.2 Drains and Culverts Construction Requirements

- Design, construct and maintain longitudinal side drains and cross drainage structures to minimize ponding and overflow onto the road or inundate private property.
- Longitudinal side drains are to have a depth of not less than 0.20m below the formation level.
- Incorporate a minimum longitudinal grade on the road surface between culvert locations (for example, 3% to 5%), to prevent any tendency for water to pond on flat sections
- Construct drainage along all realigned sections to avoid damming or obstruction of surface runoff on either side of road thus preventing subsequent erosion problems
- Replace all culverts that are either undersize and/or compromised according to the recommendations resulting from the culvert assessment.
- Ensure culvert dimensions are based on assessment of projected water flows and that they meet at the very least the minimum standard.
- Ensure that the drainage improvement recommendations are implemented for the flood prone areas and that proper drainage form part of the overall road design.
- Ensure that where there are sections proposed for vertical and horizontal alignments provide proper drainage designs for adjacent properties and landowners.
- Ensure the ditch has a uniform shape, in which obstructions that may impede or deflect flow of water are eliminated (for example, boulders or rock outcrops) since these may lead to erosion of the adjacent road aggregate.
- Install a ditch-block at locations of cross-drainage to direct flow out of the ditchline and into the culvert (for example, a block made of erosion-resistant soil). The crest of a ditch-block is to be lower than the surface of the road pavement (for example, 0.3m below the road surface) so that, in the event of impeded cross-drainage, any flow continues down the ditchline and does not overflow onto the road.
- Culvert inlets and outlets are to be provided with headwalls for erosion protection. Where necessary outfalls are to be provided and constructed of none erodible material.

- All new and replaced cylindrical culverts are to be of reinforced concrete since these are not flammable and are less likely to be washed away. Culverts of HDPE material are easier to install but are flammable and can become a fire hazard.
- All box culverts are to be of cast in place reinforced concrete.
- Provision of extra culvert pipes and mitre drains to keep flows spread out and prevent gully formation from concentrated flows.
- Where possible culverts should be designed as underpasses to act as wildlife crossings and also be fish friendly. This can be achieved by increasing the diameter of the cylindrical culverts and also encourage the use of bottomless arch or box culverts.

9.6.3 Excavation and Burrow Pit Requirements

- Ensure that that the extraction of material can be legally carried out at the identified pits.
- The development or use or river material for the road works should be at a very minimum if any. Quarries for road construction materials are to be located in non-sensitive areas.
- Ensure excavation is accompanied by well-engineered drainage to control runoff into the pit.
- Ensure that sites meet the general site criteria recommended in this study.
- Develop specific procedures for storing topsoil and for phased closure and reshaping and restoration of the pit when extraction has been completed. Include plans for segregating gravel and quarry materials by quality and grade for possible future uses. Where appropriate, include reseeding or re-vegetation to reduce soil erosion, prevent gullying, and minimize visual impacts.
- Backfill and/or restore burrow areas and quarries before abandonment if alternative uses for those sites are not planned. Areas should be restored so that they are suitable for sustainable use after extraction is completed.
- Extract material volumes from different sites to distribute the environmental impact footprint.
- Level extraction sites evenly and spread topsoil to aid in re-vegetation.
- Provide for free drainage following extraction and ensure that measures are put in place to trap sediments before discharging into the receiving environment.

9.6.4 Material Storage and Handling Requirements

The ultimate selection of the campsite and material storage site will rest on the road construction contractor since it entails at times the use of private property which requires a business agreement for its use and also a final approval for its use from DOE. Nonetheless, BET identified four possible areas to be used for construction campsite and stockpiling material (Figure 9.2). The first area identified is at 1.5 km south of the Vista del Mar Junction (WGS84 UTM: 365507.69 m E 1940224.96 m N). CISCO Construction Ltd. previously used this area during the rehabilitation the PGH from the Haulover Bridge to Airport Road. The second area identified is the parcel of land that was once occupied by a gas station about 0.75 km north of the Maxboro junction, (WGS84 UTM: 354454.00 m E 1948131.00 m N). The third area identified is an open area at Mile 23 where Mr. Polin Morales once had his campsite and is now vacant (WGS84 UTM: 349094.11 m E 1955418.83 m N). The 4th option would be Mr. Polin Morales new sand quarry site (WGS84 UTM: 348327.97 m E 1955865.27 m N)

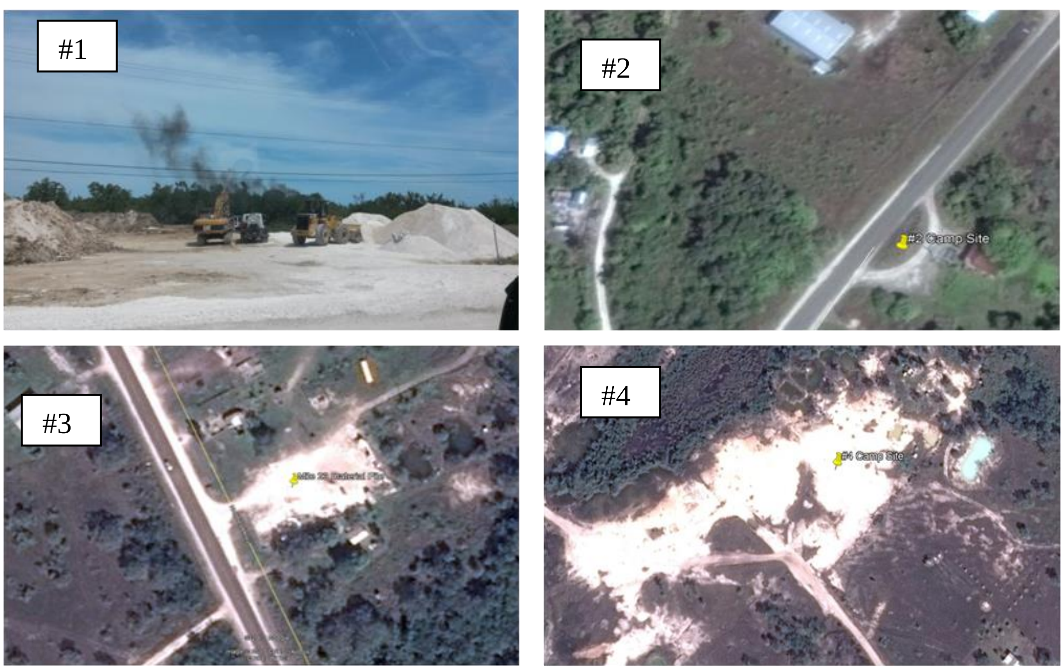


Figure 9.2: Possible Camp and material storage site at Philip Goldson Highway.

- Identify sites for temporary/permanent storage of excavated material and construction materials.
- Ensure that disposal and dumping areas of construction waste material is approved.
- Maintain proper storage facilities in all construction camps.
- Avoid pollution of waterways with stockpiled construction materials.
- Set protocols for vehicle maintenance to control contamination by grease, oil, and fuels.
- Maintain spill clean-up kits and report spills to DOE.
- Build collection channels leading to oil and/or silt traps, particularly around areas used for vehicle washing or fuelling.
- Build appropriate containment structures around bulk storage tanks and materials stores to prevent spillage entering watercourses.
- Build tanks or other separators for silt-laden material prior to allowing significant outflow into watercourses.
- Cover stockpiled construction materials, as practicable.
- Minimize the disturbance of, and reduce the spread of, ground contaminants.
- Handle, store, use, and process branded materials in accordance with manufacturer's instructions and recommendations.
- Take construction waste materials to appropriate, designated local disposal areas.
- Minimize burning of waste materials.

9.6.5 Workers Camp

- Ensure that workers camp is located away from schools, churches, and areas frequented by community members.
- Locate campsites away from waterways and provide amenities and proper sanitation facilities.
- Ensure workers camp is secure and prevents access to members of general public
- Ensure campground is maintained free of debris and pollution.
- Provide acceptable, sanitation facilities for workers.
- Properly containerize and dispose of domestic waste at workers camps.

- Locate Bulk storage of fuel and other hazardous substance away from workers structure and place appropriate signs (no smoking, cell-pones etc around these areas).
- Vegetate and seed disturbed areas of campsites after decommissioning sites.

9.6.6 Ecological Requirements

- Prevent siltation of Mexico Creek and adjacent wetlands.
- No vehicles or machinery will be washed in rivers or creeks.
- Prevent contamination of Water bodies and do not completely obstruct the flow of Mexico Creek during bridge construction.
- Remove existing excessive material from channel bed used for the construction of a detour during the Mexico Bridge Construction to restore the natural flow of Mexico Creek.
- Minimize potential for die back of vegetation areas by regular placement and maintenance of culverts and drainage system.
- Vegetate and seed disturbed areas of campsites.
- Designate work areas and work camps as "no hunting zones."
- Confine works to the exact footprint of the road wherever possible, avoid unnecessary construction vehicle turning sites, etc., and prevent physical damage to adjacent vegetation and soils.
- Maintain "soft" (vegetated) verges outside urban areas. Maintain verge width at minimum required (10 ft.) within the Section 2B to reduce habitat loss.
- Rehabilitate and replant all verges on completion of works
- Culverts/underpasses can be of significant value in helping maintain habitat connectivity for wildlife across roads, at a relatively low cost. It is recommended that drainage culverts should be constructed to be best able to act as wildlife underpasses: where possible at least 1.5 m wide and 1.5m high, and be designed to not hold water other than during drainage flow.
- Ensure that re-clearance of waterways (Black Creek, Mexico Creek and Mussel Creek) is done manually, without heavy machinery.
- Remove recovered debris (both natural and man-made) from the immediate vicinity.

- Prohibit the setting of fishing nets, or use of other means of turtle capture, by the clearance crew.
- Ensure that all clearance crew members are aware of hicatee, black howler monkeys, tapir, yellow head parrot and jabiru stork protective legislation and require them to report any illegal harvesting or transportation observed during their work period.
- Leave creek banks (Mexico Creek Black Creek and Mussel Creek) vegetation (hicatee nesting cover) undisturbed.
- Enforce a low-noise policy to be adhered to by the re-clearance work crews.
- Develop and enforce a fire-risk reduction policy to be followed by all work crew members.
- Prevent any unnecessary disturbance of the nesting jabiru storks pair adjacent to the Grace Bank Road: do not use this area for equipment or material storage, personnel camp, or other such use.
- Deter use of the Grace Bank road by work crew members for access to the River.
- Design new Mexico Creek Bridge (if the existing one is to be replaced) with flat and unobstructed base, to allow free movement along the watercourse by tapirs and other wildlife.
- Liaise with Port Authority to permit posting of no-wake signs for manatee protection along the re-cleared sections of the waterways.
- Erect no-wake signs for manatee protection along the re-cleared sections of the waterways.
- Erect road speed limit and road curve signs to help deter speeding.
- Work with communities and NGOs to record wildlife road-kills and use data to determine whether there are hotspots that merit wildlife crossing signage
- Ensure that Construction Company adheres to an operational policy for the prevention of fires.
- Construction team personnel and supervisors are to be kept informed of the issues of fire risk, and response.
- Train key construction personnel in fire-fighting techniques and equipment use.
- Maintain fire-fighting equipment on-site at construction camps and work-sites

- Waste disposal – removal of non-biodegradables to approved solid waste facility off-site, no burning of organic waste will be approved.

9.6.7 Vegetation Removal and Re-vegetation Requirements

- Where significant environmental impacts may occur, document and photograph pre-construction and post-construction conditions.
- If vegetation must be removed during wet periods, wait until just before actual construction.
- Store topsoil and preserve removed plants for later use.
- Re-vegetate with recovered plants and other appropriate local flora immediately after equipment is removed from a section of the site.
- Prevent excessive siltation of wetlands and water bodies during torrential rain events.
- Trim high vegetation along PGH ROW.
- Promote sustainable land use practices among farmers and landowners to prevent siltation and damming of stream channels, making flash floods, and inundations worse.
- Stabilize roadside slopes and drains by planting vegetation. Work with agronomists to identify native species with the best erosion control properties, root strength, site adaptability, and other socially useful properties.

9.6.8 Traffic Management Requirements

- Maintain a minimum road width open for through traffic at all times.
- Install signage to direct traffic during construction stating speed, curve, crossings, and junctions must be installed.
- Use proper signage, traffic safety equipment/warning devices and speed indicators when diverting traffic either to an alternate route or reducing to one lane.
- Employ traffic wardens at schools and other sensitive areas to control the movement of both the deviated traffic and construction traffic.
- Place fencing and safety barriers to separate the construction site from the trafficable areas.
- Use adequate night illumination and warning signs and decals to alert and warn motorist and pedestrians.

- Reduce pedestrian/vehicle conflict to ensure safety, especially through the communities.
- Install pedestrian crossings at key areas including busy trafficking areas, schools, and clinics.
- Requiring the contractor to manage construction activities to ensure that traffic can flow in both directions on the highway, especially at night thereby minimizing risks
- Maintain access to all properties, including those that are someway linked. Where access restrictions are required, the landowner should be notified as early as possible and such restrictions should be limited to daylight hours.
- Reduce congestion on roads through communities and villages, improving pedestrian safety (with reduced impact through traffic conflict) and other adverse social impacts associated with congestion, including traffic noise.
- Improve connectivity between residential development and the social infrastructure and services available.
- Improve vehicular movement across the road network and vehicular efficiency and provide greater access to alternative routes.
- Provide pedestrian and cycle carriageways across communities to enable better traffic safety.

9.6.9 Cultural Heritage

- **Archaeological:** Although there was no archaeological site identified in the immediate vicinity of the highway ROW, however, all necessary mitigation measures will be taken during the construction phase to remove the potential for any negative impact on unknown sites. The unearthing of any artefact shall cause construction activities to be suspended and the Institute of Archaeology contacted immediately.
- **Art Center:** A small art centre, 'Sandhill Art Center', is operated just on the outskirts of the Village (Mile 19 ¼) and given its location within/in close proximity to the road reserve may be adversely impacted by the road project. To this end, demolition, temporary relocation, and reconstruction will be necessary to preserve the supported activities (details to be defined in the RAP report).

9.6.10 Utilities Management Requirements

- Liaise with Belize Electricity Limited prior and during construction to ensure that necessary power poles that fall within the road reserve are relocated prior to road construction commencement.
- Liaise with Centaur Cable Company and Belize Telemedia Belize prior and during construction to ensure that necessary underground fibre optic cables that fall within the road reserve are relocated prior to road construction commencement.
- Liaise with Belize Water Services Limited and rural community to identify water mains that fall within the road reserve to ensure that works do not impact these supply pipes.
- The potential impacts on water supply were considered in determining the preferred widening alternative in order to avoid potential impacts to existing water mains

9.6.11 Community and Worker Welfare, Safety and Health Requirements

- Work during daylight not exceeding 12 hrs.
- Ensure workers from local communities are hired with minimum of 30% quota for women;
- Inform communities of construction activities.
- Ensure that the contractor responds appropriately to complaints from communities.
- Ensure early discussion and negotiation between landowners and the Ministry of Works regarding any property acquisition for the construction of roundabouts and alignments to improve road safety.
- Maintain and regularly check tools fitted with mufflers where appropriate.
- Construct noise barriers between work sites and communities.
- Maintain construction vehicles fitted with mufflers where appropriate; turn off when not in use; avoid reversing.
- Provide and ensure workers wear Personnel Protective Equipment.

- Have workers use vibration isolation and suspension systems and alternate vibration work among workers.
- Assess vibration impacts to property and discontinue where damage/injury imminent.
- Use dust suppressant measures.
- Shut off equipment when not in use and maintain in good operating condition.
- Ensure equipment has emission control devices.
- Provide proper sanitation facilities at workers camps.
- Ensure fire and medical response for the campsites and construction site.
- Ensure prompt medical attention to migrant workers to minimize the transmission of diseases within the camp and to neighbouring communities.
- Ensure that the lifestyles of construction workers do not have any negative impact on the social and economic welfare of nearby communities.

9.6.12 Mexico Creek Bridge and other large box culvert - Construction Requirements

- The bridge structures are to be such that the channel disturbance and impacts on aquatic organisms is minimized by maintaining a natural river channel bottom. Construct abutments sequentially to allow unimpeded flow of creek.
- Bridge structures are to be provided with wing walls to ensure that the bridge approaches are not undermined by river water scour effects nor the runoff from the longitudinal side drains.
- The completed bridge structures are to be provided with signs and guardrails on the approaches to minimize the possibility of impact or collision by vehicles. The reduction of these incidents will also assist in preventing oil spills from reaching the rivers.
- Establish and adhere to construction timetables during dry season.
- Divert storm water away from construction areas and away from surface water bodies.
- Use wing dams made of sand bags or silt curtains.

- Store all stripped pavement and excavated soil away from riverbanks and streams.
- Construct approaches to bridge and the deck of bridge above the maximum flood stage.
- Avoid haulage of materials through village streets and ensure loads are covered.
- Ensure no motor vehicle is washed in the creek.
- Limit and enforce speed around construction zone.
- Shut off equipment when not in use and maintain in good operating condition.
- Ensure equipment has emission control devices.
- Fit equipment with mufflers and turn off when not in use.
- Service and maintain construction heavy-duty equipment.
- Reduce traffic congestion within this zone by construction of a temporary crossing.

9.6.13 Ladyville/Lords Bank Road Construction

- Halt and divert local traffic to alternate route identified.
- Put in place with the assistance of the Police Department, safety measures to ensure compliance with the detour signs. Put in place all respective signage.
- Warn the general public via radio and television advertisement of such planned activities.
- Upgrade alternate detour to temporarily accommodate traffic within this area (Figure 9.3).

Figure 9.3: Ladyville proposed temporary bypass during PGH rehabilitation.

9.7 Indicative Costing of Mitigation Measures

Table 9.11 provides an indicative costing for the implementation of the recommended mitigation measures to address the environmental and social impacts associated with the rehabilitation of the Philip Goldson Highway and its accompanying activities. These costs are those primarily associated with capacity building and institutional strengthening of the executing and regulatory agencies involved in ensuring compliance monitoring of the ESMP. It also includes the estimated costs for land acquisition and compensation. It must be borne in mind that the major costs associated with mitigation measures have been included in the design features of the project and are part of the pre-feasibility and preliminary engineering design estimates. In addition, many of the mitigation measures recommended are based on the implementation of best management practices and good industry standards, which are shall be included as conditions in the contracts that would be issued in respect to the rehabilitation of the PGH.

Table 9.11: Indicative costing for the implementation of the recommended mitigation measures.

	ITEMS/DESCRIPTION	QTY	UNITS	RATES	COST USD
A	**LAND ACQUISITION (land area as per Golder's preliminary design)**				
1	Vista del Mar T-Junction	588	s.m.	10	5,880
2	Roundabout #1: Airport Junction	905	s.m.	10	9,050
3	Roundabout #2: Lords Bank Junction	978	s.m.	10	9,780
4	Roundabout #3: Burrell Boom Junction	1196	s.m.	10	11,960
B	**CONSTRUCTION OF THE LINK CANAL SYSTEM (Clovers Leaf)**				
1	Golder's proposal-Option 4 of reference 1547768TM0014-REVB-DRAFT consisting of; 2-30m long box culverts under PGH A 6m, 30m wide stop logs control gate across the canals close to the PGH crossing. Concrete lining of the bottom of the existing canal's to prevent vegetation growth. Sheet piling of the canal's sides to support the vertical sides. No land acquisition cost is indicated The cost is exclusive of works within the private property and maintenance.			L.S	3.8M
C	**DRAINAGE IMPROVEMENT PROGRAM**				
1	Section 1. Covered box culvert (1.5m X 1m) along Marage Road/Manta Ray Boulevard/Vista Del Mar Marina and also along Poinsettia Street up to Manta Ray Boulevard.	4100	m	750	3.1M
2	Section 1. Clearing and dredging of open drain from PGH to Vista del Mar Marina (5m x 2m)	7600	c.m.	15	114,000

Table 9.11 (cont.): Indicative costing for the implementation of the recommended mitigation measures.

	ITEMS/DESCRIPTION	QTY	UNITS	RATES	COST USD
D	**CONSTRUCTION OF THREE STABILIZATION CULVERTS** (1.5m X 1.5m) **TO SERVE AS WILDLIFE CROSSINGS ALSO**				
1	Section 1B Mile 11Culvert #1	12	m	1125	13,500
2	Section 2B Culvert #2	12	m	1125	13500
3	Section 2B Culvert #3	12	m	1125	13500
E	**MITIGATION & MANAGEMENT MEASURES**				
1	Clearing of Mexico Creek,	1	LS	7,500	7,500
2	Clearing of Black Creek	1	LS	12,500	12,500
3	Clearing of Mussel Creek	1	LS	12,500	12,500
F	**Capacity Building**				
1	Personnel for Environmental Monitoring	2 for 9mts	LS	See table 1.7	45,000
2	Water quality Monitoring	9mts	LS		25,000
3	Air quality Monitoring	9mts	LS		25,000
4	Personnel For Social Monitoring Plan(CRFP)	3 for six mts	LS	1,000 per pers. per mt	18,000
5	Part- Time Community liaison officer for SMP	3 for six mts	LS	500 per pers. per mt	9,000
6	Establishment of grievance data-base	1	only		5,000
	ITEMS/DESCRIPTION	QTY	UNITS	RATES	COST USD
G	**Training**				
1	Risk Identification and Assessment related to Roads Projects	1	only	5,000	5,000
2	Multi- media Environmental Compliance Monitoring	1	only	5,000	5,000
3	Project Management and Monitoring and Evaluation	1	only	5,000	5,000
4	Training on Grievance Mechanism	1	only	1,500	1,500
H	**Project Evaluation**				
1	Mid Term evaluation of Project performance	1	only	6,000	6,000
2	End of Project Evaluation	1	only	6,000	6,000

SY: Square Yard; LF; Linear Foot; LS: Lump Sum; mts: Months; m: meter; c.m. cubic meter; s.m. square metre

CHAPTER 10: PUBLIC PARTICIPATION PROCESS

10.1 Introduction

Public participation is not only a statutory requirement, but a process that is designed to provide interested and affected parties with the necessary and sufficient opportunities to: provide local knowledge on the Project Area; raise issues of concern; identify and confirm issues requiring further investigation in the impact assessment; influence project decisions; evaluate the results of environmental and social impacts and suggest enhancement/mitigation thereof.

Through informed and transparent public participation of interested and affected parties, effective social and environmental management/mitigation measures can be established and implemented. To this end, the PPP's design focuses on achieving the following objectives:

- Ensure that interested and affected parties are well informed about the proposed Project;
- Provide a broad range of interested and affected parties sufficient opportunity to engage and provide input and suggestions on the proposed Project;
- Verify that interested and affected parties' issues have been accurately recorded, considered and/or addressed;
- Draw on local knowledge in the process of identifying environmental and social issues associated with the proposed Project; and to involve interested and affected parties in identifying ways in which these can be addressed;
- Provide opportunities for clearing up misunderstanding about technical issues, resolving disputes and reconciling conflicting interests;
- Contributes to improving transparency and accountability in decision making;
- Contributes to maintaining a healthy, vibrant democracy; and
- Comply with statutory requirements, as per the EIA regulations.

10.2 Methodology

To achieve effective public participation in the ESIA process, communities along the existing ROW in the Study Area and PAPs were engaged, informed and consulted using various methods and techniques and their socio-economic profiles studied to ensure the use of socio-culturally appropriate participatory approaches during the consultations.

The overall PPP took into account various types, levels and techniques of engagement for completeness, inter alia:

- ✓ Inform: provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.
- ✓ Consult: obtain public feedback on analysis, alternatives and/or decisions.
- ✓ Involve: work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.
- ✓ Collaborate: partner with the public in each aspect of the decision, including the development of alternatives and the identification of the preferred solution.

To this end, the PPP process is empowering to communities as it respects their right to know and participate in decision making; undoubtedly, this is contributing positively to improved relations between and among Central and Local Government as well as improving overall transparency and accountability.

Principal among the methods and techniques used were key informant interviews, focus group discussions, probability and purposeful surveys, community meetings and the required statutory public consultation as per the EIA regulations.

As detailed in the ESBA Report, the Social Baseline Component of the ESIA Study utilized a mixed method approach and relied on the use of primary data derived from a carefully targeted survey and right-of-way census and complemented by key informant interviews, focus group discussions and direct field observations over the period March-April, 2017. Additionally, these primary data sources were further complemented by secondary data derived from the 2010

Census and relevant literature review of the Study Area comprising the villages as specified in Table 10.1.

Table 10.1: Road Sections and Communities in Study Area.

Road Section	Village
RS I: Section from Mile 8.5 – Mile 15	Ladyville and Lord's Bank
RS II: Section from Mile 15 – Mile 24.5	Sandhill, Gardenia and Biscayne

Direct Field Observations: To better understand the dynamics of the project affected communities, albeit a snapshot of community life, time was dedicated observing various sporting events in Ladyville, Lord's Bank and Sandhill as well as observing the daily routines of adults going to work and children going to school and the respective transportation and road safety issues associated with the existing road conditions across the five communities.

Key Informant Interviews and Focus Group Discussions: To deepen the understanding of issues observed, a number of key informant interviews were conducted with educators, village residents and local entrepreneurs. Additionally, focus group discussions were also conducted with the respective village councils to inform on the proposed road rehabilitation and to ascertain an overall qualitative understanding of the socio-economic development from their perspective and document key issues currently impacting their communities as well as potential impacts as a consequence of the proposed road rehabilitation. See Annex XIII A-3 for Instrumentation

Social Baseline Survey and ROW Census: The Social Baseline Survey targeted a random sample of households in each identified village using the PPS method and a 95% confidence level and 6% margin of error. The face-to-face Survey was conducted by 12 trained interviewers over the period April 3 - 13, 2017 using a semi-structured questionnaire, Annex XIII A-4.

Table 10.2: Social Baseline Survey Response Distribution.

HH located along ROW?	Result of HH Interview:	CTVC?					Total
		Ladyville	Sandhill	Lord's Bank	Gardenia	Biscayne	
Yes	completed	31	62		29	20	142
	no one at home	1	1		0	0	2
	partially completed	2	5		0	2	9
	vacant dwelling/lot	1	0		0	0	1
	no suitable respondent	0	1		0	0	1
	Total	35	69		29	22	155
No	completed	102	27	50	5		184
	no one at home	1	0	0	0		1
	refusal	0	0	1	0		1
	partially completed	2	0	2	0		4
	Total	105	27	53	5		190
Total	completed	133	89	50	34	20	326
	no one at home	2	1	0	0	0	3
	refusal	0	0	1	0	0	1
	partially completed	4	5	2	0	2	13
	vacant dwelling/lot	1	0	0	0	0	1
	no suitable respondent	0	1	0	0	0	1
	Total	140	96	53	34	22	345

The census of households was conducted simultaneously alongside the Survey and targeted all households along the right-of way, adjusting for households already included in the Survey sample listing. As detailed in Table 10.2, overall response rate for the Survey and Census is 94.5%.

Of importance to note to the overall PPP and this Report is the use of probability surveys by the BET Team to effectively gauge community concerns and level of support for the Road Project. This is of particular importance given the poor participation rates and lack of community representativeness associated with traditional public meetings. To this end, the Socio-Economic Baseline Survey included inter alia, a Module on Road Users: Issues, Concerns and Recommendations, for which summary findings are summarized further below.

.At the time of the Report preparation, the BET Team had already conducted:

- Key informant interviews/focus group discussions with women, youth, educators village chairpersons, council members, entrepreneurs and select community residents over the period February – April 2017, See Annex XIII A-2 for listing of key informants/participants;

- Socio-economic baseline survey of communities along the ROW over the period April 3 -13, 2017;
- Pre-ESIA Community Meetings across the defined road sections over the period August 20 – 31, 2017 as per schedule below[11], for listing of participants, please refer to Annex XIII A-6.

Table 10.3: Meeting Schedule.

Day/Date/Time	Community	Venue
Sunday August 20, 2017; 3:00 p.m.	Ladyville and Sandhill	Ladyville Community Centre
Thursday August 31, 2017; 7:00 p.m.	Sandhill, Gardenia and Biscayne	Sandhill Community Centre

- At this stage, the only pending PPP activity is the statutory public consultation meeting tentatively scheduled in October subject to public notice and DOE's approval of the DRAFT ESIA Study Report.

Key to the success of the PPP and an overall underpinning strategy of the BET team in this process was engagement of the village chairpersons/councillors from the PAPs communities as the first points of contact. This served not only to validate the legally established leadership in these communities, but also paved the way for the Team to better understand the socio-economic and political context of the communities, map community assets and build excellent rapport for future engagement. The chairpersons communicated their appreciation for BET's consideration and commented on the number of times activities/projects would be undertaken in their communities without any levels of information exchange much less being consulted.

10.3 Summary Issues, Concerns and Recommendations

10.3.1 Key Informant Interviews and Focus Groups

Chairpersons and councillors from the villages of Ladyville, Lord's Bank, Sandhill and Gardenia were interviewed as key informants over the period March – April, 2017 and later in June, 2017.

[11] Meetings were planned to be conducted earlier in June and July; however due to competing agenda issues with the respective village councils and then pending weather conditions, they had to be postponed twice.

Unanimously, all chairpersons/councillors are very supportive of the proposed road upgrade and see this as an opportunity for direct benefit to their communities in the form of potential employment of youth, women and men as well as indirectly via improved economic development for the area via expanded opportunities for micro-businesses and tourism. High on the list of priorities was the need for the proposed Project to hire workers from the local communities with special attention given to youth and women in what is generally perceived as a male dominated work force.

Another shared concern of the chairpersons/councillors is the safety of pedestrians and cyclists along the ROW. There are many documented cases of traffic accidents which have resulted in fatalities or serious bodily injury to villagers, inclusive of young children in school zones. These accidents are attributed to the lack of safety features and pedestrian infrastructure along the portions of the road passing through their villages particularly in Ladyville and Sandhill where the road passes immediately adjacent to schools, placing children in dangerous proximity to unregulated traffic and undisciplined drivers. In response, the chairpersons/councillors suggested as an inclusion in the Project, the construction of walkways/bicycle paths They also suggested the construction of appropriate pedestrian crossings, signage, bus stops, lighting, garbage facilities and speed bumps or other traffic calming devices in their sections of the road accesses. A recommendation for the Project to support the installation of CCTV within school zones to enforce speed limits and other traffic laws was made.

Furthermore, focus group discussions were held with youth and women from the communities of Ladyville and Sandhill. The concerns raised by these groups understandably reflect those similarly raised by the chairpersons/elders. Youth and women first addressed the existing concerns and problems with the existing road and those possibly arising from the rehabilitation work. They identified the existing concerns and problems as: the road being too narrow and needs to be widened; inadequate/lack of proper drainage; road being too dusty causing/aggravating health issues (asthmatics), especially in the dry season; road needs to be paved; terrible road conditions when it rains; and reckless drivers with the need to enforce speed laws and put more speed bumps and pedestrian crossings in place, especially within the school zones. They also identified the need for more bus stops with adequate room for pulling off the road.

When the rehabilitation is complete/during construction, these groups believe a new set of concerns will occupy the attention of villagers within the Project Area. These include: increased traffic and speeding; fast approaching traffic; the need for more speed bumps; the need for proper lighting; noise pollution; dust pollution from works; better road pavement. a need for pedestrian crossings especially for school children and the elderly; a need for highway patrols; installation of CCTVs and the potential loss of livelihood during the construction period.

In addition, these groups also focused however on the benefits that would accrue from the rehabilitation of the road accesses in their communities. They believe the rehabilitation would lead to more job opportunities, especially during the construction phase and may quite likely lead to more economic opportunities after its completion from increased local and international visitors passing through to experience the local tourist attractions (Burrell Boom, Altun Ha, Crooked Tree and Lamanai) and stopping in at the local establishments along the ROW. Another important benefit pointed out by these groups was the possibility of faster travelling time to healthcare facilities in Belize City as well as quicker response time from Police due to improved road surfacing.

Notwithstanding the perceived benefits, a core issue in need of being addressed is the potentially negative impact of the work force as it relates to sexual exploitation of adolescent girls and harassment of women by the predominantly male work force and so communities wanted to ensure that women and children would be protected.

On a final note, these focus groups recommended for inclusion in the Project, the following safety improvements to the sections of the road passing through their communities: traffic signs, pedestrian crossings, better drainage, sidewalks, and bus stops with lay-byes.

10.3.2 Survey and Census: Level of Support, Issues and Recommendations

Seventy-five per cent (75%) of all residents across the Study Area have expressed high/very-high levels of support for the proposed road rehabilitation project and a further 17% remained neutral as they reportedly were somewhat sceptical that the road rehabilitation would actually materialize given prior promises of road/general infrastructure upgrade, ST Table R-1 (Annex XIII A-1). Notwithstanding, the broad level of support, a number of issues/concerns and recommendations were also noted as summarized below.

Overall condition of the mile 8.5-24.5 segment of the PGH roadway was rated as poor/very-poor by 47% of the residents across the Study Area, Table R-2. Only one in every five resident gave a rating of good/very-good condition with a significant proportion, 32%, remaining neutral, Table R-2. During the rainy season, the road condition seemingly worsens with 59% of residents indicating poor/very poor compared to 34% during the dry season, ST Table R-3 and ST Table R-4. Furthermore, only 18% of residents rated their experience travelling the PGH by vehicle as being comfortable/very-comfortable; while a mere 5% rated their experience as a pedestrian as being safe/very-safe.

Overall, residents indicated that the three most important road features to them for the PGH are: better lighting, enforcement of speed limits and installation/maintenance of pedestrian crossings/speed humps, ST Table R-20 - R-22. At the time of the Survey, 10% of residents reported having personally been involved in/family member involved in an RTA on the PGH, Table R-26.

"Too narrow/should be widened", "people drive too fast/speeding", "no/poor lighting and "driving under the influence" were among the top ranked problems associated with the PGH road section, Table R-17 – R-19. Additionally, the dust from the existing road was identified by 61% of residents as the cause of 'problems' and 18% indicated that the dust caused health related issues for them, TST able R-10 – R-11.

With respect to mode of transport, use of public transport (56%) and personal vehicles (36%) ranked highest, ST Table R-12 – R-13. From the Survey it was apparent that the PGH forms a critical link for residents in the pursuit of their livelihoods and in accessing basic services. "Better access to services", "faster travelling time", and "safer roads for users" were among the top ranked benefits of the proposed rehabilitated PGH, St Table R-23 – R-25.

10.3.3 Consultations: Pre-ESIA Meetings

In the pre-ESIA consultations, two local-level sessions were organized and conducted as per schedule above; a total of fifty-two persons (36 men; 16 women) participated in the consultations, Table 10.4. Prior to the public meetings, paid community mobilizers distributed a total of 2000 invitational flyers, Annex XIII (A-5), to residents across the ROW;

notwithstanding the added effort, level of participation was low. The public meetings were organized in collaboration with the respective village councils.

Table 10.4: Community Consultation Participation

Road Section (RS)	Community	Meeting Date	Participants		
			Male	Female	Total
RS-I	Ladyville/Lord's Bank	Aug 20	15	6	21
RS-II	Sandhill/Gardenia/Biscayne	Aug 31	21	10	31
Total			36	16	52

By design, and to facilitate documentation of participants' concerns and recommendations, consultation forms were prepared and distributed to those participants who wanted to express their concerns/recommendations in writing, Annex XIII (A-7). Otherwise, concerns/recommendations were shared verbally and documented by BET personnel; participants chose the latter modality.

Main issues and concerns raised and recommendations offerred mirrored those previously documented and raised by the viallage councils, key informants, focus group participants and wider survey respondents inter alia: Poor Road Conditions: pavement, edges, shoulders; Speeding in residential areas and school zones; DUI: Driving under the influence of alcohol; Sidewalks and Crossings; Bus-byes; Lighting; Flooding; and Employment and Livelihoods.

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