THE ENVIRONMENTAL IMPACT ASSESSMENT FOR HIGHWAY 2000, THE MOUNT ROSSER BYPASS, LINSTEAD TO MONEAGUE

DATE: **2007 August**

CLIENT: **Bouygues Travaux Public (Jamaican Branch)**

WORK DONE BY: **EnviroPlanners Limited**
20 West Kings House Road
Kingston 10

TABLE OF CONTENT

LIST OF PLATES

LIST OF APPENDICES

EXECUTIVE SUMMARY

Introduction

This document presents the findings of an Environmental Impact Assessment of the proposed Highway 2000, Mount Rosser Bypass, Linstead to Moneague being proposed by TransJamaica Limted. EnviroPlanners Limited was contracted by Bouygues Travaux Publics (Jamaican Branch) to carry out the Environmental Impact Assessment, as part of the permitting requirements stipulated by the National Environment and Planning Agency (NEPA).

Proposed Development

The Linstead to Moneague segment of Highway 2000 (H2K) requires the construction of a two lane, dual carriageway all-purpose road that is essentially rural in nature. The Highway will run to the east of the current A1 Highway and will cover a distance of 23.9 km.

The Highway begins with an interchange at the Linstead Bypass, St. Catherine at chainage 0+000, near **Byndloss**. The alignment travels through the districts of (Stirling Castle), Russell Pen, Treadways and Palm, following a similar alignment to that of the existing rural road.

The highway then heads easterly, through Mountain Pass and towards the district of Enfield, running through agricultural land before curving towards Mullock. From here, the highway traverses rolling or irregular terrain of Mount Zion, Schwallenburgh and Faith's Pen, most of which had been mined previously for bauxite.

From Km 19+000, the highway follows a similar alignment to the existing A1 Highway, passing on the eastern side. The highway then crosses the A1 Highway at the Unity Valley Farms, passing near Green Haven and Grier House, and then reconnecting with the A1 Highway, behind **Moneague**, on the segment to Golden Grove.

Methodology

A multi-disciplinary team of experienced scientists and environmental professionals was

assembled to carry out the required resource assessment, generation and analysis of baseline data, determination of potential impacts, recommendation of mitigation measures and possibly alternative. An interactive approach among the environmental team members and other project professionals was adopted. The EIA team worked very closely with the other project team members including the project manager, civil engineers, surveyors and quality assurance team
The team utilized the Charette-style approach to data gathering, analysis, and presentation whereby team members conducted the reconnaissance investigations together to determine the critical elements for analysis and the issues to be highlighted for
the design and planning process. Team meetings were held to discuss the progress of investigations and analyses and facilitate integration of data toward an understanding of
the systems at work in both the natural and built environment.

Baseline data for the study area was generated using a combination of:

- Field studies
- Analysis of maps, plans, aerial photos
- Review of engineer's reports and drawings
- Review of background project documents
- Structured Interviews
- Social Surveys
- Laboratory analyses
- Internet Searches
- Agency requests and document searches

Written environmental searches were undertaken through the WRA, NWC and ODPEM. In addition website searches of the National Environment and Planning Agency (NEPA), Meteorological Service of Jamaica, and NWC was undertaken to obtain any further relevant information. The results of the written searches are included in Appendix IX.

Detailed methodologies for the physical, biological and socio-economic aspects of the baseline survey are presented in the report. Additionally, limitations to the study were identified.

Regulatory Framework

An application for an environmental permit was submitted to the National Environment and Planning Agency (NEPA). NEPA requested that an environmental impact assessment be done. Terms of Reference were prepared by EnviroPlanners Limited based on the NEPA generic terms of reference and submitted to NEPA for approval. Several pieces of legislation were identified as being relevant to the project and included the Natural Resources Conservation Authority Act, Clean Air Act, the Public Health Act, and the Natural Resources conservation Authority (Air Quality) Regulations.

The Existing Environment

The highway starts at approximately 285053mE (UTM) at the Linstead Bypass then heads northwest, paralleling the existing A1 roadway, towards the community of Threadways, then loops to the east then north-westward around Recess Pen and Baliey Town. It then continues northwest along Mullock and Faith's Pen continuing on to just west of Moneauge along the Golden Grove main road at 2008533mN (UTM).

The by-pass will see the construction of a 24 km long, two lane, tolled dual-carriage with the expressed purpose of by-passing the existing, but now outmoded, A1 highway that skirts the eastern side of the Mount Diablo. The highway will alleviate much of the traffic congestion now common on the existing A1 road.

The Physical Environment

The rainfall data was obtained from the Meteorological Service of Jamaica (Met Service) website dated May 2007. The 30 year (1951 – 1980) mean precipitation for St. Catherine and St. Ann ranges from 50 – 250 mm.

Published geological information indicates the solid geology of the site comprises Mid-Eocene to Oligocene members of the White Limestone Group. The soil profile across the alignment comprises mainly clay loams a few metres thick.

Several caves are also know to occur in close proximity to the alignment. The closest, the Potato Hill cave chamber (244,000 mE, 173,000 mN) is about 40m south of the alignment at km 12+000. Its elevation is 460 masl and around 36m in length, no depth was recorded. The second is the Schwallenberg Cave (240,500mE, 175,000mN) located 350m west of km 16+500. The

cave is located at an altitude of 470 masl and is described as a cave leading to a shaft; it has a recorded explored depth of 76m and is 73m in length.

Hydrology

The proposed project will not be a significant charge on water resources in the area traversed by the alignment. The only constantly manned stations are the toll plaza at Russell Pen (km 0+600), operation support building and the food concession stands. All other persons using the highway will be transient. The water demand will be minimal and will be easily met by the existing localised mains supplies.

The bypass crosses water systems of the Byndloss Gully that represents a portion of the head waters Rio Cobre hydrological basin. First and second, possibly third order streams (or gullies) allied the Byndloss Gully are intersected.

One groundwater well (Unity Valley at 237962 mE and 177798 mN) is located within 100m west of the alignment (circa km 21+000). Its pumping rate is recorded as 1091 m^3/d. Given its proximity it may fall within the RoW of the alignment. The well is registered to Glencore Alumina Jamaica.

Drainage

The drainage system will be designed to accommodate Jamaican climatic conditions, comprising heavy rainfall and rapid runoff, through a system of drainage with two components:

- The minor drainage system, which will collect runoff resulting from the more frequent storm events and will be designed to convey the runoff to the outlet at the receiving major drainage system. The minor drainage system will consist of kerbs, channels, storm sewers, small cross-culverts and roadside ditches.

- The major drainage system consists of the large existing gullies and rivers, which take and discharge the runoff from the minor drainage system.

Crossings will be designed to comply with the recommended average number of 2.6 per km and will be designed with a minimum diameter of 900 mm. Ditches will be of a trapezoidal design

and their size will be consistent with the calculated flow to be accommodated. In general, all ditches will be lined, where their longitudinal gradient is greater than 3% or where in-situ material is likely to scour), with concrete, rip rap, grouted stone, or precast concrete elements.

Generally, the 3.6 m wide median will slope away from the barrier but, where the road is super-elevated and the paved surface slopes toward the median, a system of prefabricated channels shall be installed alongside the median barrier with longitudinal pipes discharging transversely at intervals to the outside of the carriageway.

Natural Hazard

Flooding historically has not been significant problem within the southern and mid-sections of the alignment, however, the northern section has records of historic flooding at the Moneague and Tadmore groundwater lakes since 1810. Flooding here is a combination of geology (sinkholes/depressions), intense rainfall and topography.

The OAS seismic risk maps of Jamaica shows that the project site lies in an area that can expect a Modified Mercalli Intensity of 7 with a 10% chance of exceedance in any 50 year period. Expected horizontal ground velocity is projected to be approximately 18 cm/sec and 245 – 270 gals for horizontal ground acceleration reducing toward the west. These predictions assume a significant earthquake event in the eastern parishes – the most geologically active part of the island. A more localised event may along the rejuvenated Mount Diablo Fault increase these values.

Prehistoric landslides have been documented west of Ewarton, St. Catherine in the Mount Diablo area. Geographically, major slides in Jamaica are located principally in the Cretaceous basement rocks where they are exposed in the Inliers and coupled with steep slopes. Given the above their will be a significantly increased landslide risk along the alignment as it curves across the Mount Diablo Fault by Mango Grove and heads west passing Bailey Town until it reaches the limestone plateau of Mount Zion.

Air Quality and Noise

The noise levels recorded at the stations monitored are currently well within the NEPA guideline for perimeter noise. The site is not impacted by the any surrounding activities..

Respirable particulates levels were well within the recommended ambient air quality PM10 guidelines established by NEPA.

Biological Environment

The project site under investigation covers a distance of approximately 15 kilometers starting in the alluvia plain of Linstead then assending the limestone hills of Mount Diablo to Berkshire a distance of ten kilometres. The other section investigated runs for a distance of five kilometres, over primarily limestone deposits, from Faiths Pen to Moneague. The biological resources are very diverse as is also the case for land utilization. The area from chainage 0+000 to 10+000 is occupied by significant amount of settlements and population centres spanning the communities of Bynlos, Treadways, Bermady and Molluck.

The land use can be generally described as:

- Housing interspersed with subsistent farming.
- Grasslands interspersed with shrubs.
- Agricultural lands for large expanses of sugar cane and citrus.
- Tropical dry forest.

The area between chainage 18+500 to 24+000, which cover the communities of Faith Pen, Unity Valley, Pheonix Park and Moneague,.

The land use here can generally be described as:

- Tropical dry forest
- Pasture lands
- Housing

The vegetation associated with these areas are typical of that which is expected it be found in the interior areas of Jamaica. Based on the flora survey the vegetation type can be grouped into four sections, as follows:

- Section A - 0+000 to 7+500 (housing intrespersed with subsistence farming and commercial farm lands).
- Section B - 7+500 to 10+000 (primary limestone dry forrest).

- Section C - 18+500 to 21+600 (primary limestone forest interspersed with mined out grasslands and subsistence farming.
- Section D - 21+600 to 24+000 (pasture land along with housing and subsistence farming).

Socio-economic Environment

Currently the lands are used for subsistence farming of crops such as corn and yam in the Moneague area and some sugarcane in the Linstead area.

A community centre is currently being constructed in the Phoenix Park Community.
There are no other planned developmental activities apart from the highway project within the next 3 years.

Unemployment in many of the communities is high and the construction of the highway can increase the availability of jobs for communities impacted by it both directly and indirectly. It will also provide direct employment for skilled and unskilled labourers – e.g. masons, flagmen. Direct employment – vendors and cook shops.

The construction of the Highway will also facilitate easier access to other communities and towns.

Many residents do not perceive that construction will hinder commuter travel. However thirty eight percent (38%) of the persons polled believe that it will be very disruptive, especially in terms of dust and noise nuisance.

Project Awareness:

- 96% of the persons interviewed were aware of the project
- 92% feels that the project is needed. (64% believe that it is greatly needed).

Public Perception of Project

- 66% of the residents believe that the highway will attract more business to their communities.
- 52% believes that it will destroy the natural environment
- 64% believe that it will not contribute to flooding

- 84% believes that it will cause noise and dust nuisance during construction.
- Some persons believe that it will contribute to place being a 'ghost town' as vehicles are diverted to highway. The Faiths Pen Vendors see the bypass as having negative impact on their business and would like to see incorporated in it a rest stop or access and exit points off the highway.
- 86% believes it will provide jobs (directly and indirectly).
- 38% believes that it will be disruptive, especially during the construction phase. This was more evident among the Faiths Pen Food vendors who saw it as reducing the level of business activity they now experience. Their fear is that motorists will bypass their stall when they use the Mt. Rosser By-pass. They welcome it but want it planned with them in mind – e.g. Rest Stop or direct exit and re-entry of the highway for persons who wish to visit Faiths Pen.
- 60% feels that the project will affect the community
- 86% - Better transportation
- 52% - project will destroy natural environment; 48% - No
- 57% - believe it will damage farm land

Public Health and Safety

There is a police station in Moneague and a clinic. The nearest major hospital is in St. Anns Bay. There is also a fire station in St. Anns Bay. St. Anns Bay is a major town in the parish of St. Ann.

The communities polled seemed organized. Each community either had a church or was in close proximity to one. Others had citizens association, farmers group and youth groups. The communities also had access to hospitals and clinics, police stations and fire departments. The social linkages have the ability to positively impact the social health of residents within these communities. The highway will increase access to hospitals, clinics, the police and the fire departments. One resident remarked that it will reduce the number of persons who die in transit because of lengthy delays getting to hospitals.

Potential Impacts and Mitigation Measures

Loss of terrestrial habitat and biodiversity

The clearing and removal of trees and vegetation during the highway construction will result in the loss of a significant part of the existing dry limestone forest and, as a consequence, a reduction in the habitat for the flora and fauna. Noise, vibrations, and intrusive activities related to construction works also will tend to scare away the fauna remaining in close proximity to the site after vegetation clearance.

The overall objective of this mitigation is to minimize and where possible restore disturbed areas

- Site clearance must be preceded by identification and relocation of all endemic plants and ecologically valuable specimens that can be later used for re-vegetation of exposed areas. Bird feeding trees should also be planted as part of the re-vegetation process
- Establish a plant nursery to preserve the plants for relocation until ready for replanting. These plants are to be placed and maintained in a plant nursery on site until ready for transplanting. These activities should be guided by an appropriate and approved management plan.
- Site clearance should seek to avoid removal of the large trees.
- A plan must be put in place for the rescue, relocation and treatment of fauna injured in the clearing process

Loss of land use options

Construction of the highway will involve the large scale removal of vegetation and the erection of permanent road surface on what is essentially a green field site. This will result in a loss of the options for alternative use of the land and thus represents an irreversible commitment of land resources. Loss of the option to utilize this stretch of land for any other purpose can be considered to be a negative impact.

Mitigation is not considered for this impact but is addressed in section 9 under the heading Consideration of Alternative.

Soil erosion

Vegetation clearance and excavation works for construction of the highway will expose soils in the affected areas leaving them vulnerable to erosion by surface run-off during heavy rainfall. The hilly topography of the area exacerbates this potential of this negative impact.

- As much as possible, minimize the area of exposed soil at any given time.
- Re-vegetate exposed soils with appropriate species as soon as possible.
- During construction direct flows from heavy runoff away from areas that are threaten by erosion.

Noise

The use of heavy equipment during site clearance and construction works will inevitably generate noise, which may create a nuisance for nearby residents and workers. This is a negative impact but is not considered to be significant, as the duration will be short-term.

- Local residents within a distance of impact should be given notice of intended noisy activities so as to allow then to make any necessary preparation.
- Workers operating equipment that generates noise should be equipped with the appropriate noise protection gear.
- Construction activities that will generate disturbing sounds should be restricted to normal working hours.

Dust

The site clearing and excavation activities will produce fugitive dust which may result in increased levels of air borne particulate matter. This situation will be worst during the dry season and during times of prevailing wind. Most of the highway alignment is outside of population centre, and this impact will be of greater significance in areas close to human settlement. The occurrence of dusting is periodic and short-term, lasting for the duration of the construction activity.

- Exposed surfaces should be regularly wetted in a manner that effectively keeps down the dust.

- Stockpiles of fine materials (e.g. marl) should be wetted or covered with tarpaulin during windy conditions.
- Workers on the site should be issued with dust masks during dry and windy conditions.
- Local residents within a distance of impact should be given notice of intended noisy activities so as to allow then to make any necessary preparation.

Consideration of Alternatives

For this section, Linstead to Moneague five alternatives were considered.

- The existing road through Ewarton and Mount Diablo with normal maintenance;
- The existing road through Ewarton and mount Diablo with local improvements;
- The proposed route corrider, derived from the design prepared by Lamarre Valois International in 1974 with local changes, is composed partially of a new alignment, and partially of local improvements of the existing road;
- The proposed route corridor is composed partially of a new alignment, and partially of local improvements of the existing road;
- This route corridor has for objective to bypass the town of Ewarton, which creates a bottleneck to the transit traffic.

Outline Monitoring Programme

If a permit is granted for the proposed development, and before site preparation and construction activities begin, a Monitoring Programme should be prepared for submission to NEPA, for their approval. The Monitoring Programme should include several components, including an inspection protocol; parameters to be monitored; frequency of monitoring and reporting procedures. The duration of the monitoring programme should be for the entire construction period, with monthly reporting. The Monitoring Programme cannot be prepared in detail before the permit is received from NEPA as Terms and Conditions of the permit must be taken into consideration, and included in the monitoring programme as appropriate.

- **During the Construction Phase:** precautionary engineering measures (such as cut-off trenches, etc) should be implemented to reduce sediment run-off and prevent it from reaching existing drainage features. Nothing which could cause pollution, including silty water, should enter such any watercourse.
- All temporary fuel, oil and chemical storage must be sited on an impervious base within a bund and secured. The base and bund walls must be impermeable to the material stored and of an adequate capacity. Storage at or above roof level should be avoided.
- Leaking or empty oil drums must be removed from the site immediately and disposed of via a licensed waste disposal contractor to landfill.
- Washings from concrete mixers, lorries, paint or paint utensils should not be allowed to flow into any drain or watercourse.
- Ensure that depressions/sinkholes are not used for fly-tipping or other waste disposal.
- **Post construction:** General monitoring of drainage pathways to ensure they are properly maintained.

1.0 INTRODUCTION

This document presents the findings of an Environmental Impact Assessment (EIA) for the proposed construction of the Mount Rosser Bypass, Linstead to Moneague by Bouygues Travaux Publics (Jamaican Branch). The EIA will encompass Linstead to Mount Zion and Faiths Pen to Moneague excluding Mount Zion to Faith Pen (Phase I). This area referred to as Phase I (Km 10 + 000 to 18 + 500) was excluded as it consist mainly of mined out bauxite lands and so only required the preparation of a Flora and Fauna survey (please see Flora and Fauna Study in Appendix I). This survey was done and permit obtained for the construction of Phase I.

EnviroPlanners Ltd. was contracted by Bouygues Travaux Publics (Jamaican Branch) to carry out the EIA as part of the permitting requirements as stipulated by the regulatory agency, the National Environment and Planning Agency (NEPA).

1.1 Purpose

EnviroPlanners Ltd. submitted an application for a development permit to the NEPA. The application was accompanied by a Project Information Form (PIF) and supporting documentation. NEPA responded to that application with a request that an Environmental Impact Assessment (EIA) be conducted on the proposed development, based on their review of the permit application (Appendix II). NEPA supplied Generic Terms of Reference and requested modification of these Terms of Reference to be specific to the project. The modified Terms of Reference were submitted to NEPA for their approval and a response obtained.

The TOR is outlined in Section 4.0 and the completed document as approved by NEPA is presented in Appendix III.

2.0 PROJECT BACKGROUND

The Highway 2000 Project (H2K) began in 2001, when the Prime Minister of Jamaica announced that Bouygues Travaux Publics of France was selected as the preferred bidder for Phase 1 of the Project. The upgrade of the Old Harbour Bypass was the first phase of the project and was followed by the construction of the Kingston to Bushy Park segment, and then the Portmore Causeway segment.

The H2K Project will link Kingston to Montego Bay through the parishes of Kingston & St. Andrew, St. Catherine, Clarendon, Manchester, St. Elizabeth, Westmoreland and St. James. The Highway will also have a North-South link, originally intended to connect Bushy Park and Ocho Rios, traversing the parishes of St. Catherine and St. Ann. The total length of the highway is approximately 230 km, with an anticipated right-of-way of 100m.

In 1996, a "Feasibility Study and final design for upgrading Highway A1 from Spanish Town to Moneague and St. Ann's Bay" was commissioned by the Government of Jamaica (overseen by the then Ministry of Local Government & Works) and conducted by Société Nouvelle INGEROUTE.

At that time, and as now, the existing road was not acceptable for the large traffic flow and there are a number of specific problems that reduce the traffic capacity severely. These include the following:

- Traffic may be totally interrupted for a few hours to a few days in the Bog Walk Gorge, when the Rio Cobre is in flood,
- The Flat Bridge (a one-lane bridge), in the Bog Walk Gorge, creates a permanent bottleneck,
- Very long delays can be experienced between Ewarton and Moneague in the case of accidents or any blockage of the road, and
- On the same section, the crossing of Mount Diablo is very difficult for loaded trucks.

The study was split into two major stages. Phase I involved a preliminary identification of alternative routes and a comparison of alternatives to identify the best option. This 'best option'

was determined by evaluating the technical, environmental and economical aspects of the alternatives. Phase II focused on the preliminary engineering design of the selected 'best option'.

In 1999, a Strategic Environmental Assessment (SEA) of the Highway 2000 Project was commissioned by the National Development Bank of Jamaica Ltd., as part of the development of the functional planning design. The SEA report provided guidelines for design and alignment within the context of a 1 km corridor, which had been selected by the "least constraining methodology". The report recommended areas for further study in detailed project-level environmental impact assessments (EIAs) that would be necessary to support the application for an environmental permit. *The current alignment of the North-South link does not follow the route put forward in this SEA.*

TransJamaican Highway Ltd., a specially created subsidiary of Bouygues Travaux Publics, is the developer responsible for the implementation of the project, and Bouygues Travaux Publics Jamaican Branch is the contractor.

Segment I of the Highway 2000 Project has been divided into two phases as follows:

- Phase IA will include extensive work on the Portmore Causeway as well as work from Kingston to Sandy Bay. This will include construction of four lanes from Kingston to Bushy Park (2x2) and doubling of the Old Harbour Bypass (by construction of a second 2-lane carriageway.

- Phase IB will include construction of the highway from Sandy Bay to Williamsfield, incorporating the existing Melrose Bypass, construction of the May Pen interchange and a main toll plaza at Williamsfield.

The new alignment for the North-South link closely follows the 'best option' as put forward by the Société Nouvelle INGEROUTE study. As stated previously, this link was originally intended to link Bushy Park and Ocho Rios but now would incorporate use of some existing road (non-tolled sections) and the creation of new roads (tolled sections). This will include:

- Spanish Town (tie-in with Highway 2000) to Bog Walk, bypassing the Bog Walk Gorge, (Tolled section)

- Bog Walk to Linstead (Free section)
- The Mount Rosser Bypass, from Linstead to Moneague (Tolled section)
- Moneague to Golden Grove (Free section)
- Golden Grove to Ocho Rios (Tolled section)

The Mount Rosser Bypass is one section of this North-South link, which will be merged with the entire alignment in due course. This segment is seen as an urgent need, and has therefore been given priority.

3.0 PROJECT DESCRIPTION

3.1 Alignment, Crossings and Toll Plaza

3.1.1 Aligment

The Linstead to Moneague segment of Highway 2000 (H2K) requires the construction of a two lane, dual carriageway all-purpose road that is essentially rural in nature. The Highway will run to the east of the current A1 Highway and will cover a distance of 23.9 km.

The Highway begins with an interchange at the Linstead Bypass, St. Catherine at chainage 0+000, near **Byndloss**. The alignment travels through the districts of (Stirling Castle), Russell Pen, Treadways and Palm, following a similar alignment to that of the existing rural road.

The highway then heads easterly, through Mountain Pass and towards the district of Enfield, running through agricultural land before curving towards Mullock. From here, the highway traverses rolling or irregular terrain of Mount Zion, Schwallenburgh and Faith's Pen, most of which had been mined previously for bauxite.

From Km 19+000, the highway follows a similar alignment to the existing A1 Highway, passing on the eastern side. The highway then crosses the A1 Highway at the Unity Valley Farms, passing near Green Haven and Grier House, and then reconnecting with the A1 Highway, behind **Moneague**, on the segment to Golden Grove.

3.1.2 Crossings

The following table gives information on the structures associated with the highway.

Location	Bridge Type	Overpass/Underpass	Structure Type
Km 0+930	Field Connector	Overpass	Composite
Km 1+620	Field Connector	Underpass	Concrete Box
Km 3+340	River Crossing	Underpass	Concrete Box
Km 3+950	Local Road	Underpass	Concrete Box
Km 5+5100	Field Connector	Overpass	Composite
Km 5+600	River Crossing	Underpass	Concrete Box
Km 5+700	Field Connector	Overpass	Composite
Km 16+500	Field Connector	Underpass	Concrete Box
Km 17+700	WINDALCO Road	Underpass	Concrete Frame
Km 18+450	Field Connector	Overpass	Composite
Km 21+600	Local Road	Underpass	Concrete Box
Km 22+850	Local Road	Underpass	Concrete Box
Km 23+400	Field Connector	Underpass	Concrete Box

3.1.3 Toll Plaza & Equipment

In order to facilitate operation as a toll road, fibre optic cables will be laid along the entire length of the highway. The toll plaza is expected to have seven lanes. The proposed toll plaza building will be similar to that of the Vineyards Toll Plaza, and the canopy and equipment will be similar to that of the Spanish Town Plaza.

It should be noted that lighting along the highway would only be in the vicinity of the Toll Plaza and the interchanges.

3.2. Phasing and Timetable

The project is scheduled to be concluded in 30 months. The project has been divided into the following phases to suit the programme of work and acquisition of land:

Phase 1: Km 10+000 to 18+000

Phase 2: Km 18+000 to 22+000

Phase 3: Km 22+000 to 23+890

Phase 4: Km 5+000 to 10+000

Phase 5: Km 0+000 to 5+000.

3.3 Construction camp/Site Yard

The construction camp will be located in the Palms community, in the vicinity of the field connector at Km 5+100. The camp will be approximately 200m x 200m and will take into consideration storm water and surface water drainage requirements, location of interceptors, as well as wastewater and sewage requirements.

3.4 Cut & Fill

All fill materials will be obtained mainly from the cut and transported by trucks to the designated fill areas.

Quarries will be identified based on:

1. Proximity to project,
2. Material type required
3. Type of approval from authorities.

Should BYTPJ need to establish a quarry, the necessary licenses/approvals will be sought.

3.4.1 Transportation requirements

All motorized vehicles within the site, excluding those on public roads, shall be restricted to a maximum speed of 20 km per hour (in the site yard) and 50 km per hour (on the alignment) by putting up speed limit signage at appropriate locations.

Haulage and delivery vehicles shall be confined to designated roadways inside the site.
The Production Team shall ensure that vehicles transporting dusty materials are fitted with side and tailboards. Materials transported by vehicles shall be covered, with the cover properly secured and extended over the edges of the side and tailboards.

Dusty materials shall be dampened before transportation.

3.5 Waste Management

All waste materials will be managed in accordance with the project environmental management plan in a manner that will promote waste avoidance and minimisation. Waste materials will be disposed of in accordance with the relevant laws, guidelines and best practices.

Waste management options can be categorised in terms of preference from an environmental viewpoint whereby the more preferable options have the least impacts and provide for enhanced sustainability. A waste management hierarchy shall be applied on site as follows:

- Avoidance and minimisation, for example by:
  - Selecting products that will cause no or minimal environmental impacts
  - Not generating waste, which would be achieved by changing or improving practices and design;
- Reuse of materials, thus avoiding disposal; and
- Treatment and disposal, in accordance with relevant laws, guidelines and best practice.

3.5.1 Chemical Wastes

Paint residues, lubricants and other oily wastes will be classified as chemical wastes and special controls will be imposed to regulate storage, labelling, transport and disposal.

3.5.2 Construction Waste

Waste material may include any excavation spoil, sewage, waste water or effluent containing sand, cement, silt or any other suspended or dissolved material to flow from the site onto any adjoining land, storm drain, sanitary sewer, or any waste matter or refuse to be deposited anywhere within the site or onto any adjoining land.

When handling the waste material, the following measures shall be undertaken:

- The strategy for management and disposal of all wastes arising from the project will be based on the principle of segregation and re-use on site followed by disposal at Parish Council approved reclamation, public dump or landfills as appropriate;

- Surplus excavated material is to be exported to a Parish Council approved public dumping areas;
- All construction waste shall be sorted on site into inert and non-inert materials. Non-inert materials such as wood and other materials including glass, plastics, steel and metals shall be disposed of to landfill. Inert materials like soil, sand, rubble, shall be separated from non-inert material and disposed of at Parish Council approved public dumps or spoil sites
- For disposal of other inert construction wastes, principles shall be established to:
    - Maximise re-use of materials on site,
    - Segregate wastes to ensure that the minimum quantities are disposed of at Parish Council approved landfills,
    - Maximise reclamation of materials by the public.
- In addition, quantities of site fencing and timber for the building work shall be reused where possible. Those materials that cannot be re-used will require disposal at a Parish Council approved landfill;
- All vehicles carrying waste shall have properly fitted side- and tailboards, and the materials being transported shall be securely covered.

3.5.3 General (Non Construction) Waste

The following principles shall be adopted for General (Non Construction) Waste:

- All works areas shall be cleaned of general litter and refuse daily.
- General refuse and litter shall be stored in enclosed bins or compaction units separate from construction or chemical wastes. A reputable waste collector shall be used to remove general waste and litter off site for disposal.
- Refuse shall not be burned at any Construction Area.
- General refuse may be generated by food service activities on site, so reusable rather than disposable dishware shall be used if feasible.
- Office wastes shall be reduced through recycling of paper, if volumes are large enough to warrant collection. Participation in a local collection scheme shall be considered, if available.

3.6 Project Location

Figure 1. A map detailing the location of the project (orange line).

4.0 TERMS OF REFERENCE

The Environmental Impact Assessment to be completed by EnviroPlanners limited shall include but not limited to the following:

1) Objectives of the project
2) A complete description of the existing site proposed for development outlining the main elements of the project with particular emphasis on the details of the highways as it relates to the number of lanes as well as the plans for future expansions. A map will be included to identify the proposed location of the project site.
3) Significant environmental issues of concern will be identified through presentation of baseline data which will take into consideration social, cultural and heritage information. An assessment of the public perception of the proposed development will be done through public consultations and the use of social survey instruments such as questionnaires.
4) Identification of Policies, Legislation and Regulations relevant to the project.
5) Prediction of the likely short, medium and long term impact of the development on the environment, including direct, indirect and cumulative impacts, and their relative importance to the design of the development's facilities.
6) Identify any mitigation action to be taken to minimize predicted adverse impacts and provide associated costs where applicable and practical.
7) Develop an Environmental monitoring Plan which will ensure that the mitigation measures are adhered to during the implementation phase.
8) Describe the alternatives to the project.
9) Conclusions

EnviroPlanners Limited will provide full details of the following in fulfillment of an Environmental impact Assessment:

1. Task # 1. Description of the Project

a. Detailed description of the area proposed for the project
b. Detailed description of the elements of the projects such as the alignment, crossings, bridges and toll plaza
c. Description of proposed off site facilities such as construction camps and infrastructure service
d. Description of project related decommissioning and abandonment of works and/or facilities.
e. Information on location, general layout and size of project area.
f. Use of maps, site plans, photographs and graphics aids where necessary.
g. Description of construction, pre-construction and post construction activities

2. Task # 2. Description of the Environment/Baseline Studies Data Collection and Interpretation

Presentation of baseline data which will be utilized to describe the study areas in respect of the following:

i. Physical

a. Detailed description of the existing geology and hydrology. Determination of storm water run-offs and the effect of the project on the ground water. Slope stability issues will be explored.
b. Water quality of any existing rivers, pond or streams in the vicinity or to be impacted by the development. Water Quality Indicators should be but not limited to suspended solids, colour, turbidity, nitrates, phosphates, oil & grease and faecal coliform.
c. Climatic conditions and air quality in the area of influence including particulate emissions from stationary or mobile sources, NOx, Sox, wind speed and direction, precipitation, relative humidity and ambient temperatures,

d. Noise levels of undeveloped site and the ambient noise in the area of influence.
e. Obvious sources of existing pollution and extent of contamination.
f. Availability of solid waste management facilities.

ii. Biological

a. Description of flora and fauna in the sphere of influence of the proposed project with emphasis on rare, threatened, endemic, protected, endangered species.
b. Description of the different ecosystem types (e.g. caves and sinkholes if present) and the species they support.
c. Identification of any nocturnal species as well as migratory species which use the project site
d. Species dependence, habitat/niche specificity, community structure and diversity will be considered.
e. Note the importance of the biological diversity of the area
f. Note the invasive and economically important species.

iii. Socio-economic & Cultural

a. Present and projected population
b. Present and proposed land use
c. Planned developmental activities
d. Identification and summary of private land acquisition
e. Local economic benefits and cost overall and on an individual community basis
f. Implications of the project during the construction phase for resident commuter travel and travel times
g. Accommodation for construction workers
h. Access to, and delivery of health, educational and social services and emergency support to local communities
i. Employment

j. Distribution of income, goods and services
k. Recreation
l. Public heath and safety
m. Historical importance of the area
n. Public perception

3. Task # 3. Legislative & Regulatory Considerations

Describe the pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that will specifically apply to the project, so as to ensure compliance.

There are several pieces of legislation, regulation and policies which are applicable to developments of this nature. Some that will be examined are; the Toll Road Act, Wild Life Protection Act, NRCA Act, Public Health Act, and the Town and Country Planning Act.

4. Task # 4. Determine the Potential Impact

Identify impacts related to highway construction activities, such as land clearing, land cutting spoil disposal and possible land filling. Distinguish between significant impacts that are positive and negative, direct and indirect and short and long term. Identify impacts that are cumulative, avoidable or irreversible. Identify any information gaps and evaluate their importance for decision-making. Special attention will be paid to the effect of the project on:

- Water quality - surface and underground
- Drainage pattern and flooding
- Waste disposal
- Changes to land use
- Future development
- Geological, archaeological, historical, architectural and any other naturally occurring features/resources
- Atmospheric pollution

- Biodiversity and ecosystem
- Socio-economic and cultural
- Habitat loss or disturbance
- Noise levels ,

5. Task # 5. Drainage Assessment

Storm water run-off will be examined and assessed on the basis of;

- Run-off during construction and the necessary mitigation for flooding and sedimentation of water bodies.
- Rivers, gullies and other wetland crossing and potential impact of the construction and constructed features on the water bodies.
- Run-off during operation and the necessary mitigation for flooding and sedimentation of water bodies.

6. Task # 6. Mitigation & Management of Potential Impacts

Identify possible measures to prevent or reduce significant negative impacts to acceptable levels with particular attention paid to drainage and dispersal/sedimentation control, as well as measures to minimize disruption to existing fauna and flora. Cost the mitigation measures, equipment and resources required to implement those measures. Propose mechanisms for investigating claims for compensation put forward by affected stakeholders.

7. Task # 7. Monitoring Plan

Identify the critical issues and features requiring monitoring to ensure compliance to mitigation measures and develop an Environmental Monitoring Programme indicating the parameters to be monitored, the recommended frequency and duration of the monitoring.

8. Task # 8. Analysis of Alternatives to the proposed Project

Describe the alternatives examined for the proposed project that would achieve the same objective including the “no action alternative. This includes consideration of historical use of the area and future planned developments where applicable.

9. Task # 9. Public Consultation & Presentation

Stakeholder groups such of Environmental Organizations NGO & CBO will be identified and consulted during the period of conducting the EIA. Consultation will be through surveys, interviews and meetings.

A public Presentation of the EIA report will be done to inform and seek discussion and comments from the public on the proposed project. The implementation of the project will span two parishes, St. Catherine and St. Ann. Two Public Meeting are therefore proposed for Linstead and Moneague

5.0 LEGISLATION AND REGULATORY CONSIDERATIONS

This section presents the legislation and regulations pertinent to the proposed Highway. Comments are made where they are felt to be helpful in relating the project to the existing regulations, policies and legislation.

5.1 National Legislation – Natural Environment

5.1.1 Natural Resources Conservation Authority Act (1991)

The Natural Resources Conservation Authority Act was passed in the Jamaican Parliament in 1991 and provided the basis for the establishment of the Natural Resources Conservation Authority (NRCA) with primary responsibility for ensuring sustainable development in Jamaica through the protection and management of Jamaica's natural resources and control of pollution. Sections 9 and 10 of the NRCA Act stipulate that an Environmental Impact Assessment (EIA) is required for new projects and existing projects undergoing expansion.

The body is also responsible for investigating the effect on the environment of any activity that may cause pollution or which involves waste management. Sections of the Act that relate specifically to pollution control state that:

(i) No person shall discharge on or cause or permit the entry into waters, on the ground or into the ground, of any sewage or trade effluent or any poisonous noxious or polluting matter.

(ii) No person is allowed to construct or reconstruct or alter any works designed for the discharge of any effluent.

The Act also empowers the authority to require of any owner or operator of a pollution control facility information on the performance of the facility, the quantity and condition of effluent discharged and the area affected by the discharge of such effluent.

The Authority has the right to consult with any agency or department of Government having functions in relation to water or water resources to carry out operations to:

(a) Prevent pollutants from reaching water bodies.

(b) Remove and dispose of any polluting matter or remedy or mitigate any polluted water body in order to restore it.

5.1.2 Environmental Review and Permitting Process (1997)

The Environmental Permit and License System (P&L), introduced in 1997, is a mechanism to ensure that all developments in Jamaica meet required standards in order to minimize negative environmental impacts. The P&L System is administered by NEPA, through the Applications Secretariat of the Application Branch. Permits are required by persons undertaking new development which fall within a prescribed category. Under the NRCA Act of 1991, the NRCA is authorized to issue, suspend and revoke permits and licences if facilities are not in compliance with the environmental standards and conditions of approval stipulated.

An applicant for a Permit or License must complete an application form as well as a Project Information Form (PIF) for submission to the NRCA.

5.1.3 Wildlife Protection Act (1945)

The Wildlife Protection Act of 1945 prohibits removal, sale or possession of protected animals, use of dynamite, poisons or other noxious material to kill or injure fish, prohibits discharge of trade effluent or industrial waste into harbours, lagoons, estuaries and streams, and authorizes the establishment of Game Sanctuaries and Reserves. Protected under the Wildlife Protection Act are six species of sea turtle, one land mammal, one butterfly, three reptiles and several species of birds including rare and endangered species and game birds.

5.1.4 The Endangered Species (Protection, Conservation and Regulation of Trade) Act (2000)

This Act deals with restriction on trade in endangered species, regulation of trade in species specified in the schedule, suspension and revocation of permits or certificates, offences and penalties, and enforcement. Many species of reptile, amphibian and birds that are endemic to Jamaica but not previously listed under national protective legislation, or under international legislation, are listed in the Appendices of this Act.

5.1.5 The Natural Resources (Prescribed Areas)(Prohibition of Categories of Enterprise, Construction and Development) Order (1996)

The island of Jamaica and the Territorial Sea of Jamaica have been declared a Prescribed Area. No person can undertake any enterprise, construction or development of a prescribed description or category except under and in accordance with a permit. The Natural Resources Conservation (Permits and Licenses) Regulations (1996) give effect to the provisions of the Prescribed Areas Order.

5.1.6 Water Resources Act (1995)

The Water Resources Act of 1995 established the Water Resources Authority (WRA). This Authority is authorized to regulate, allocate, conserve and manage the water resources of the island. The Authority is also responsible for water quality control and is required under Section 4 of the Act to provide upon request to any department or agency of Government, technical assistance for any projects, programmes or activities relating to development, conservation and the use of water resources.

It is the responsibility of the WRA as outlined in Section 16 to prepare, for the approval of the Minister, a draft National Water Resources Master Plan for Jamaica. Areas to be covered in this Draft Master Plan of 1990 included objectives for the development, conservation and use of water resources in Jamaica with consideration being given to the protection and encouragement of economic activity, and the protection of the environment and the enhancement of environmental values.

Section 25 advises that the proposed user will still have to obtain planning permission, if this is a requirement, under the Town and Country Planning Act. In addition, Section 21 of the Act stipulates that if the water to be used will result in the discharge of effluents, an application for a license to discharge effluents will have to be made to the Natural Resources Conservation Authority or any other relevant body as indicated by the Minister.

With regard to underground water, Section 37 states that it is unlawful to allow this water to go to waste. However, if the underground water "interferes or threatens to interfere with the execution or operation of any underground works", it will not be unlawful to allow the water to go to waste in order to carry out the required works provided that there is no other reasonable

method of disposing of the water. The Authority also has the power to determine the safe yield of aquifers (Section 38).

5.1.7 Country Fires Act (1942)

Section 4 of the Country Fires Act of 1942 prohibits the setting of fire to trash without prior notice being given to the nearest police station and the occupiers of all adjoining lands. In addition, a space of at least fifteen feet in width must be cleared around all trash to be burnt and all inflammable material removed from the area. Section 6 of the Act empowers the Minister to prohibit, as may be necessary, the setting of fire to trash without a permit. Offences against this Act include:

- Setting fire to trash between the hours of 6.00 p.m. and 6.00 a.m. (Section 5a);
- Leaving open-air fires unattended before they have been completely extinguished (Section 5b);
- Setting fires without a permit and contrary to the provisions outlined in Section 6 (Section 8);
- Negligent use or management of a fire which could result in damage to property (Section 13a);
- Smoking a pipe, cigar or cigarette on the grounds of a plantation which could result in damage to property (Section 13b).
- ***Vegetation clearance will be required but no burning is anticipated to facilitate this; however, the Developer should note the legal requirements for burning of vegetation.***

5.1.8 Quarries Control Act (1983)

The Quarries Control Act of 1983 established the Quarries Advisory Committee, which advises the Minister on general policy relating to quarries as well as on applications for licenses. The Act provides for the establishment of quarry zones, and controls licensing and operations of all quarries. The Minister may on the recommendation of the Quarries Advisory Committee declare as a specified area any area, in which quarry zones are to be established and establish quarry zones within any such specified area.

Section 5 of the Act states that a license is required for establishing or operating a quarry though this requirement may be waived by the Minister if the mineral to be extracted is less than 100 cubic metres. Application procedures are outlined in Section 8. The prescribed form is to be filed with the Minister along with the prescribed fee and relevant particulars. The applicant is also required to place a notice in a prominent place at the proposed site for a period of at least 21 days starting from the date on which it was filed.

Any quarries used to provide material for the project should be licensed.

5.1.9 The Pesticides (Amendment) Act (1996)

The Pesticides (Amendment) Act of 1996 amended sections of the principal act, which came into effect in 1975 and established the Pesticides Control Authority. This Act gives the Authority the responsibility of controlling the importation, manufacture, packaging, sale, use and disposal of pesticides. Section 11 states that the Authority is required to eep a register or record of all relevant information such as registered pesticides, restricted pesticides, pest control operators and persons licensed to import or manufacture pesticides. Under Section 16 of the Act, the Authority may also, with the approval of the Minister, make regulations which relate to areas such as:

- Aerial application of pesticides;
- Supervision required for the use of pesticides, the prescribed protective clothing to be worn and other precautionary measures;
- The permissible levels of pesticides to be used;
- The periods during which particular pesticides may or may not be used on certain agricultural crops;
- The disposal of pesticides and packages.

5.1.10 Clean Air Act (1964)

This act refers to premises on which there are industrial works, the operation of which is in the opinion of an inspector likely to result in the discharge of smoke or fumes or gases or dust in the air. An inspector may enter any affected premise to examine, make enquiries, make tests and take samples of any substance, smoke, fumes, gas or dust as he considers necessary or proper for the performance of his duties.

Exhaust and Emissions should meet the National Standards

5.1.11 The Natural Resources Conservation Authority (Air Quality) Regulations, 2002

Part I of this Act stipulates license requirements and states that every owner of a major facility or a significant facility shall apply for an air pollutant discharge license. Part II speaks to the stack emission targets, standards and guidelines.

The Act states that no person shall emit or cause to be emitted from any air pollutant source at a new facility, any visible air pollutants the opacity or pollutant amount of which exceeds the standards.

Every owner of a facility with one or more air pollutant source or activity shall employ such control measures and operating procedures as are necessary to minimise fugitive emissions into the atmosphere, and such owner shall use available practical methods which are technologically feasible and economically reasonable and which reduce, prevent or control fugitive emissions so as to facilitate the achievement of the maximum practical degree of air purity.

Under this Act a "major facility" is described as any facility having an air pollutant source with the potential to emit:

(a) one hundred or more tonnes/y of any one of total suspended particulate matter (TSP);

(b) particulate matter with a diameter less than ten micrometres (PM10);

(c) sulphur oxides measured as sulphur dioxide (SO2);

(d) carbon monoxide (CO);

(e) nitrogen oxides (NOx) measured as equivalent nitrogen dioxide;

(f) five or more tonnes/y lead;

(g) ten or more tonnes per year of any single priority air pollutant; or

(h) twenty-five or more tonnes per year of any combination of priority air pollutants;

The Air Quality Standards would become applicable with the operation of the heavy equipment during construction of the Highway.

Table 1: Standard for Air Pollutants

Parameters	Annual	24 h	1 h	8 h
Total Suspended Particulates	60	150		
PM10	50 (diameter <10 micrometer)	150		
Primary	80	365		
Secondary	60	280		
Sulphur Dioxide			700	
Carbon Monoxide			40,000	10,000
Nitrogen Dioxide	100			

5.1.12 Noise Standards

Jamaica has no national legislation for noise, but World Bank guidelines have been adopted by the National Environment and Planning Agency (NEPA), and are used for benchmarking purposes along with the draft National Noise Standard that is being prepared. The guidelines for daytime perimeter noise are 75 decibels and 70 decibels for nighttime noise.

5.2 National Legislation – Social Environment

5.2.1 Town and Country Planning Act (1958)

Section 5 of the Town and Country Planning Act authorizes the Town and Country Planning Authority to prepare, after consultation with any local authority, the provisional development orders required for any land in the urban or rural areas, so as to control the development of land in the prescribed area. In this manner, the Authority will be able to coordinate the development of roads and public services and conserve and develop the resources in the area.

Any person may, under Section 6 of the Act, object to any development order on the grounds that it is:

- impractical and unnecessary;
- against the interests of the economic welfare of the locality.

However, if the Minister is satisfied that the implementation of the provisional development order is likely to be in the public interest, he may, under Section 7 (2) of the Act, confirm it with or without modification by publishing a notice in the Gazette. Section 8 of the Act also gives the Minister the authority to amend a confirmed development order. Section 10 of the Act states that a development order must include:

- • clearly defined details of the area to be developed;
- • regulations regarding the development of the land in the area specified;
- • formal granting of permission for the development of land in the area.

If the provisions of section 9A of the Natural Resources Conservation Authority (NRCA) Act apply to the development, the application can only be approved by the Planning Authority after the NRCA has granted a permit for the development (Section 11 (1A)). The Authority may impose a "tree preservation order" under Section 25 of the Act if it considers it important to make provision for the preservation of trees and woodlands in the area of the development.

This order may:

- prohibit the cutting down, topping, lopping or willful destruction of trees;
- secure the replanting of any section of the woodland area in which trees were felled during the forestry operations permitted under the order.

The tree preservation order is not applicable to the cutting down of trees which were already dead, dying or had become dangerous and the order can take effect only after it has been confirmed by the Minister.

The Minister can, under Section 26 of the Act, make regulations to restrict and regulate the display of advertisements in any area to be developed if he considers this to be in the interest of public safety. Section 28 of the Act empowers the local authority to require the owner or occupier of land in the development area to take the steps necessary to ensure its proper maintenance.

5.2.2 Land Development and Utilization Act (1966)

Under Section 3 of the Land Development and Utilization Act (1966), the Land Development and Utilization Commission is authorized to designate as agricultural land, any land which because of its "situation, character and other relevant circumstances" should be brought into use

for agriculture. However, this order is not applicable to land, which has been approved under the Town and Country Planning Act for development purposes other than that of agriculture. Among the duties of the Commission outlined in Section 14 of the Act is its responsibility to ensure that agricultural land is "as far as possible, properly developed and utilized".

5.2.3 Public Health Act (1976)

The Public Health (Air, Soil and Water Pollution) Regulations 1976, aim at controlling, reducing, removing or preventing air, soil and water pollution in all possible forms. Under the regulations given:

i. No individual or corporation is allowed to emit, deposit, issue or discharge into the environment from any source.
ii. Whoever is responsible for the accidental presence in the environment of a contaminant must advise the Environmental Control Division of the Ministry of Health and Environmental Control, without delay.
iii. Any person or organization that conducts activities which release air contaminants such as dust and other particulates is required to institute measures to reduce or eliminate the presence of such contaminants.
iv. No industrial waste should be discharged into any water body which will result in the deterioration of the quality of the water.

5.2.4 The National Solid Waste Management Authority Act (2001)

The National Solid Waste Management Authority Act (2001) is “an act to provide for the regulation and management of solid waste; to establish a body to be called the National Solid Waste Management Authority and for matters connected therewith or incidental thereto”. The Solid Waste Management Authority (SWMA) is to take all steps as necessary for the effective management of solid waste in Jamaica in order to safeguard public health, ensure that waste is collected, sorted, transported, recycled, reused or disposed of, in an environmentally sound manner and to promote safety standards in relation to such waste. The SWMA also has responsibility for the promotion of public awareness of the importance of efficient solid waste

management, to advise the Minister on matters of general policy and to perform other functions pertaining to solid waste management.

Solid waste will be generated during the construction of the Highway and will require the removal and proper disposal of vegetative matter, which is cleared for construction, construction rubble and site wastes ***(please see EMP as outlined in Appendix IV)***

5.2.5 Jamaica National Heritage Trust Act (1985)

The Jamaica National Heritage Trust Act of 1985 established the Jamaica National Heritage Trust (JNHT). The Trust's functions outlined in Section 4 include the following responsibilities:

- To promote the preservation of national monuments and anything designated as protected national heritage for the benefit of the Island;
- To carry out such development as it considers necessary for the preservation of any national monument or anything designated as protected national heritage;
- To record any precious objects or works of art to be preserved and to identify and record any species of botanical or animal life to be protected. Section 17 further states that it is an offence for any individual to:
    - willfully deface, damage or destroy any national monument or protected national heritage or to deface, damage, destroy, conceal or remove any mark affixed to a national monument or protected national heritage;
    - alter any national monument or mark without the written permission of the Trust;
    - remove or cause to be removed any national monument or protected national heritage to a place outside of Jamaica.

The JNHT has been contacted officially to advise them of the project and to determine if there are any relevant listings on their Sites and Monuments Records. (Appendix V). Staff of the JNHT visited the site with members of the EIA Professional Team.

5.2.6 Land Acquisition Act (1947)

Section 3 of the Land Acquisition Act (1947) empowers any officer authorized by the Minister to enter and survey land in any locality that may be needed for any public purpose. This may also involve:

• Digging or boring into the sub-soil;
• Cutting down and clearing away any standing crop, fence, bush or woodland;
• Carrying out other acts necessary to ascertain that the land is suitable for the required purpose.

The Minister is authorized under Section 5 of the Act to make a public declaration under his signature if land is required for a public purpose provided that the compensation to be awarded for the land is to be paid out of the:

• Consolidated Fund or loan funds of the Government;
• Funds of any Parish Council, the Kingston and St. Andrew Corporation or the National Water Commission.

Once the Commissioner enters into possession of any land under the provisions of this Act, the land is vested in the Commissioner of Lands and is held in trust for the Government of Jamaica in keeping with the details outlined in Section 16. The Commissioner shall provide the Registrar of Titles with a copy of every notice published as well as a plan of the land. The Commissioner will also make an application to the Registrar of Titles in order to bring the title of the land under the operation of the Registration of Titles Act.

5.2.7 Registration of Titles Act (1989)

The Registration of Titles Act of 1989 is the legal basis for land registration in Jamaica, which is carried out using a modified Torrens System (Centre for Property Studies, 1998). Under this system, land registration is not compulsory, although once a property is entered in the registry system the title is continued through any transfer of ownership.

5.3 International Legislative and Regulatory Considerations

5.3.1 Convention on Biological Diversity

The objectives of the Convention on Biological Diversity are "the conservation of biological diversity, sustainable use of its components and the fair equitable sharing of the benefits arising out of the utilization of genetic resources". This is the first global, comprehensive agreement which has as its focus all aspects of biological diversity: genetic resources, species and ecosystems. The Convention acknowledges that the "conservation of biological diversity is a common concern of humankind and an integral part of the development process". In order to achieve its goals, the signatories are required to:

- Develop plans for protecting habitat and species.
- Provide funds and technology to help developing countries provide protection.
- Ensure commercial access to biological resources for development.
- Share revenues fairly among source countries and developers.
- Establish safe regulations and liability for risks associated with biotechnology development.

Jamaica's Green Paper Number 3/01, entitled *Towards a National Strategy and Action Plan on Biological Diversity in Jamaica,* speaks to Jamaica's continuing commitment to its obligations as a signatory to the Convention.

6.0 METHODOLOGY AND APPROACH

6.1 General Approach

A multi-disciplinary team of experienced scientists and environmental professionals was assembled to carry out the required resource assessment, generation and analysis of baseline data, determination of potential impacts and recommendation of mitigation measures. The members of the EIA Professional Team are given in Appendix VI. An interactive approach among the environmental team members and other project professionals was adopted and was facilitated by team meetings as required.

The team utilized the Charette-style approach to data gathering, analysis, and presentation whereby team members conducted the reconnaissance investigations together to determine the critical elements for analysis. Team meetings were held to discuss the progress of investigations and analyses and facilitate integration of data toward an understanding of the systems at work in both the natural and built environment.

Baseline data for the study area was generated using a combination of:

- Field studies
- Analysis of maps, plans, aerial photos
- Review of engineer's reports and drawings
- Review of background project documents
- Structured Interviews
- Social Surveys
- Laboratory analyses
- Internet Searches
- Agency requests and document searches

Written environmental searches were undertaken through the WRA, NWC and ODPEM. In addition website searches of the National Environment and Planning Agency (NEPA), Meteorological Service of Jamaica, and NWC was undertaken to obtain any further relevant information. The results of the written searches are included in Appendix IX.

6.2 Physical Environment

6.2.1 Site and Situation

A definition of the study area was determined based on the drainage areas traversed by the bypass road. These boundaries were determined based on road profile maps and field reconnaissance along open and traversable access ways. Baseline data collection on the study area was conducted and included climate, hydrology, geology, hydrogeology, topography, soil socioeconomic, flora and fauna.

All issues material to the site, such as rainfall, groundwater pollution incidents, flooding incidents, and other critical facilities were reviewed within a 5 km radius of the site.

The available data that was referenced for this study is listed below:

- HIGHWAY 2000 Project, Preliminary Design Phase, Drainage and Hydrology Report Volume I & 11, June 2000. The document draws heavily on this report due project constraints outside the influence of the author.
- Satellite Photographs taken from Google Earth's website.
- 1:12,5000 Topographic Map Sheets 83A, 83C, 84A and 84B.
- 1: 50,000 (Imperial) Series Geological Sheets 18 and 19 dated 1978 and undated, respectively.
- Water Resources Authority (WRA) Data Request – Highway 2000 date June 2007.
- Moneague Flooding Report PowerPoint Presentation by WRA.
- Scanned sections III (p. 1 to 16) of Ingeroute A1 Upgrading Feasibility Study Final Report c. 1996.
- Office of the Disaster Preparedness and Emergency Management (ODPEM).
- Internet searches of NEPA and other websites.

Data was garnered from field reconnaissance from June to August 2007, aerial photographs, previous site reports and intrusive site reports done and current public domain reports held within various governmental and non-governmental organizations.

6.2.2 Climate

The climate information such as rainfall was obtained from the National Meteorological Services.

6.2.3 Hydrology

The hydrological assessment was made using a combination of the Rational Equation for highway sections and WinTR-55 for the medium to small catchments. The Rational Method was coupled with Crystal Ball v7 a simulation program that helps you analyze the risks and uncertainties associated with any Excel spreadsheet models. Crystal Ball generates thousands of possible outcomes using Monte Carlo simulation[1]. WinTR-55 is a single-event, rainfall-runoff small watershed hydrologic model. The model generates hydrographs from both urban and agricultural areas and at selected points along the stream system. Rainfall Intensity values were obtained from equations developed in the Highway 2000 Project of June 2000.

6.2.4 Geology, Topography and Soil

Data was generated from published geological information as well as assessment of the site through field reconnaissance from June to August 2007, aerial photographs, previous site reports and intrusive site reports done and current public domain reports held within various governmental and non-governmental organizations

6.2.5 Drainage

Data was collected, reviewed and analyzed to provide analysis of the change in drainage patterns, issues related to potential for ponding, and any history of flooding on the site. This will include:

a) Drainage for the site during construction to include mitigation for sedimentation to the aquatic environment,

b) Drainage for the site during operation, to include mitigation for sedimentation to the aquatic environment,

[1] The Monte Carlo simulation is a type of spreadsheet based simulation which randomly generates values for chosen uncertain variables over and over to simulate a model outcome as the inputs vary. Results are presented using a probability distribution frequency curve (PDF).

c) Drainage control for crossings of rivers and/or gullies, to include impacts that drainage control features could have on aesthetics, water quality and sedimentation of rivers and/or gullies

6.2.6 Storm water runoff

Data was collected, reviewed and analyzed to effect discussion of the suitability of the conceptual Storm Water Drainage Plan for the highway.

Comment on the potential for increased changes to flows, channel shifting, bedload movement and stream banks to the coastal environment as the available data provides. Other effects of storm water, such as the input of oil and grease into the aquatic environment will be discussed and mitigation measures to reduce same.

The comments made on runoff are based on other published documents for the larger catchments. The smaller catchments are based on rainfall intensity equations developed in the Highway 2000 Project report of June 2000.

6.2.7 Natural Hazards Risks

Data was reviewed to provide an assessment of the natural hazard risk as it relates to flooding, landslides and seismicity.

6.2.8 Air Quality

i. Sampling Procedures

This sampling procedure follows the methods described in Airmetrics MiniVol users guide. This sampling procedure details the principles which will be implemented for BYTPJ projects.

ii. Apparatus

In accordance with the stated documents

iii. Sampling Installation

a). AirMetrics

For location that are "secure", where no possible interference with the equipment is possible, follow MiniVol users guide.

b). BYTPJ

For locations that are "non-secure", where persons, animals etc… can easily get in contact with the equipment, the following was done:

- A secure protection device (BYTPJ Environmental Sampling Drum) was installed at the designated location in a concrete base, ensuring that the protection device was facing toward work area.
- The sampling device was prepared as mentioned in MiniVol users guide (section 4 "Particulate matter sampling") and the equipment was installed inside the protective drum on the internal shelf.
- A filter which was conditioned and weighed in accordance with the "Particulate Filter Handling and Weighing" procedure was installed.
- The sampling device was retrieved. The filter was recovered following instructions in procedure "Particulate Filter Handling and Weighing" (SFD 5822)

iv. The sampling was completed by filling the Air sampling Certificate (SFD 5039)

Table 2: Location of Air Sampling Station

No.	Direction	Km
1	X: 246497, Y: 166910	0 + 000
2	X: 245882, Y: 168108	1 + 300
3	X: 242143, Y: 173635, Z: 612	14 + 600
4	X: 240748 Y: 175193, Z: 507	16 + 500
5	X: 239878 Y: 176738, Z: 487	18 + 450
6	X: 236990, Y: 180293	23 + 500

6.2.9 Noise

The sites that coincided with the Air Quality Station were selected for monitoring noise (see Table 2. above). Noise level readings, wind direction and any unusual noise sounds were recorded. In addition before and after survey, the instrument was calibrated.

6.2.10 Water Quality

Water quality was assessed through review of data from the Water Resources Authority.

6.3 Biological Environment

6.3.1 Terrestrial Flora

The approach taken for the study was to first conduct a recognisance mission through the project area to identify the variations in vegetation types that would have resulted form the mining and/or farming activities that had interrupted the landscape in that area. Information from the recognisance was used to derive a sampling plan that would ensure a comprehensive capture of the flora throughout the project area.

At strategic points along the proposed path of the high way the centre line was identified and the area sampled within 50M on either sides of the centre line.

Detailed notes were taken during the survey and photographs of all species taken to assist with identification where the species were not immediately identifiable.

Flora Assessment

The vegetation present was assessed using walk-through and the point centered quarter method. Each plant species encountered along the walk through was identified and recorded. The physical and biotic environments were also recorded. Notes were taken with regard to the tree species, status and habitat type. Common tree species were noted as well other species of interest

6.3.2 Terrestrial Fauna

Avifaunal Census

The Point count method was employed in the execution of this study. It is based on the principle of counting birds at a defined point or spot and determining the distance of each bird sensor. The point is selected and then all birds contacts (seen and heard) are recorded with a determination of distance given (less than 25 m or greater than 25m). this is done for a pre-determined time usually ten minutes before moving to another point a specified distance away (100-200 metres) *{Bibbi et al 1998). This method used* 20 points done over a three day period following a path through the project area which followed the direction of the proposed highway.

Notation of species observed between survey points was done and added to the generated species list.

Weaknesses of Point Count Method

As with all survey techniques there are weaknesses which influence overall results. The following are some factors which affect the census techniques used

1. Time of day – the best time for conducting a census is in the morning from sunrise to about 10:00 a.m. It is recognized that as the day continues the ability to detect birds decreases due to lack of movement (Wonderle 1994)
2. Tine of Year – The change in behaviour of birds during the breeding and non-breeding seasons affects detection. However for this report the assessment was done in the breeding season when birds are more vocal (Wonderle 1994)
3. Weather – things such as wind, rain, fog or if the day is too hot affect the results of the census
4. Summer count versus Winter count – the count conducting the project area were done in the summer months therefore incorporating both residence and summer migrant birds however such habitats are known to be utilized by winter migrants and these summer counts would not incorporate these birds.

Survey observation activities were also conducted during the night to ensure that nocturnal species were observed.

6.4 Socio-economic Environment

To determine the cultural and social factors associated with the construction of the Mount Rosser By-Pass, members of the communities impacted by it were interviewed and a review of economic and social literature was conducted. These were undertaken to ascertain information to satisfy the following factors as outlined in the approved terms of reference provided by NEPA.

- Present and projected population
- Present and proposed land use
- Planned developmental activities
- Identification of private land acquisition
- Local economic benefits and cost to communities
- Implication of the project during the construction phase for resident commuter travel and travel times

- Accommodation for construction workers
- Access to, and delivery of health, education and social services
- Recreation
- Public health and safety
- Historical importance of the area
- Public Perception
- Project awareness and acceptance

6.4.1 Communities Surveyed

A random sampling of 260 individuals from the parishes of St. Ann and St. Catherine, from communities that will be impacted by the construction of the Mount Rosser By-Pass was conducted. This covered a total of 22 communities (St. Ann - 11; St. Catherine – 11).

Communities polled:

1. Grierfield
2. Rosehall
3. Charliemont Farm (Scheme)
4. Treadways
5. Palm
6. Mount Pass District
7. Byndloss
8. Rose Villa
9. Grant Land
10. Russell Pen
11. Charliemont
12. Moneague Town
13. Silk Field
14. Phoenix Park
15. Golden Grove
16. Faiths Pen
17. Happy Content/ Unity Valley

18. Rivers Head
19. Schwallenburg
20. Rosemont
21. Friendship
22. Cross Road Banks

6.4.2 Demographics and Livelihood

Information on these areas was generated through interviews, observations and one and one discussions with residents.

6.4.3 Public Consultation Process

A key factor in making projects successful is to have "buy in" and acceptance by persons directly and indirectly impacted by the project. As such, in collecting information about the communities to be impacted by the development of the Mount Rosser By-Pass, residents were interacted with to determine awareness levels, centers of influence and community leaders, acceptance of the project and the most appropriate place to have the public presentations. Generally persons welcomed the project as something that will contribute to the economic and social development of the areas impacted by it.

The level of organization within some of these communities will facilitate the public consultation process. 99% of the persons polled were members of a church. This will make it easier to communicate project information and get feedback from communities during the consultation process. The church, community based organizations such as youth clubs and citizens association; Faiths Pen Vendors Association, farmers association, public health personnel, health care personnel, police and fire personnel will be targeted for the public presentations.

7.0 THE EXISTING ENVIRONMENT

7.1 The Physical Environment

7.1.1 Site and Situation

This desktop report was complied from limited field reconnaissance, current public domain reports held within various governmental and non-governmental bodies and internet searches.

The highway starts at approximately 285053mE (UTM) at the Linstead Bypass then heads northwest, paralleling the existing A1 roadway, towards the community of Threadways, then loops to the east then north-westward around Recess Pen and Baliey Town. It then continues northwest along Mullock and Faith's Pen continuing on to just west of Moneauge along the Golden Grove main road at 2008533mN (UTM), see Figure 1 above.

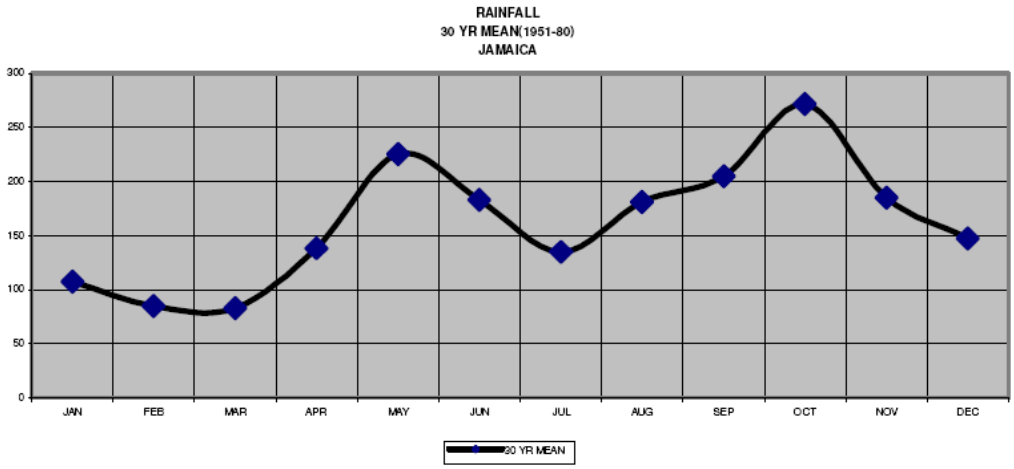
The site walkthrough was done on May 10, 2007 to visually appreciate the route of the by-pass. Follow up site walkover was done on four occasions from July to August 8, 2007 to review areas of concern such as flood-prone areas highlighted by the desktop review.

The by-pass will see the construction of a 24 km long, two lane, tolled dual-carriage with the expressed purpose of by-passing the existing, but now outmoded, A1 highway that skirts the eastern side of the Mount Diablo. The highway will alleviate much of the traffic congestion now common on the existing A1 road.

7.1.2 Climate

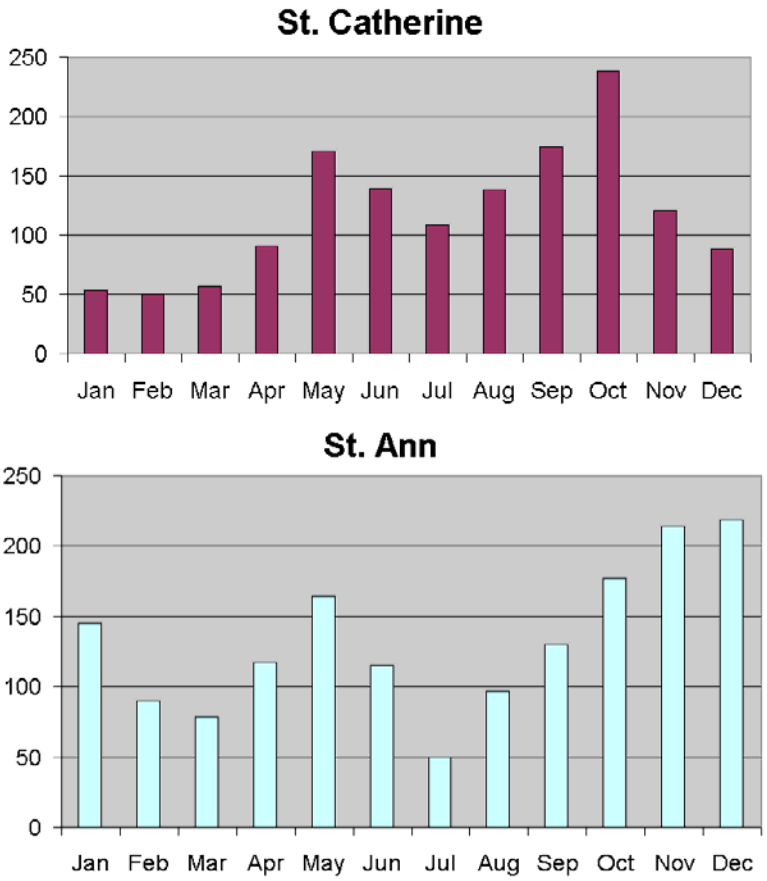
Rainfall

The rainfall data was obtained from the Meteorological Service of Jamaica (Met Service) website dated May 2007. Generally, Jamaica's rainfall pattern is bimodal (See figure 3 below) with rainfall peaks occurring in May and October and the drier periods occur in February/March and July.



• Figure 3 - 30-yr mean precipitation pattern across Jamaica (1951-1980) – taken from www.metservice.gov.jm

The 30-year mean rainfall patterns are presented below for the parishes of St. Catherine and St. Ann (all rainfall depths are in mm):



Current rainfall patterns show a 20% decline in St. Catherine and a marginal 7% increase for St. Ann when compared to their respective long-term averages for the month of June 2007. The previous two months, April and May 2007, showed declines and increases respectively.

On a more regional scale, global warming models[i], suggests that changes in the Caribbean climate will be linked negatively to temperature changes suggesting that, "the bigger the temperature rises, the larger the change in precipitation." The areas most likely to experience summer drying trends are the larger islands, such as Cuba, Jamaica and Haiti/Dominica Republic. But the report stresses that precipitation changes are very difficult to predict with certainty, and it should always be borne in mind that there is a natural variability, from month-to-month, year-to-year and decade-to-decade. On balance it may be that Jamaica experiences shorter more intense rainy periods which will increase risks of natural hazards that are associated with intense rainfall events, such as groundwater flooding and landslides.

7.1.3 Hydrology

Existing and Projected Water Demand

The proposed project will not be a significant charge on water resources in the area traversed by the alignment. The only constantly manned stations are the toll plaza at Russell Pen (km 0+600), operation support building and the food concession stands. All other persons using the highway will be transient. The water demand will be minimal and will be easily met by the existing localised mains supplies.

Groundwater and Surface Water Resources

The bypass crosses water systems of the Byndloss Gully that represents a portion of the head waters Rio Cobre hydrological basin. First and second, possibly third order streams (or gullies) allied the Byndloss Gully are intersected. Drawing (DRW-LN-TEC-D0020-A.dwg; dated 21.05.07) outline design plan layout anticipates the following surface water crossings:

Km	Type	Crossing	Structure	Discharges to:
3+340	Underpass	River (Byndloss Gully tributary)	Concrete Box	Byndloss Gully
5+600	Underpass	River (Byndloss Gully Tributary)	Concrete Box	Byndloss Gully

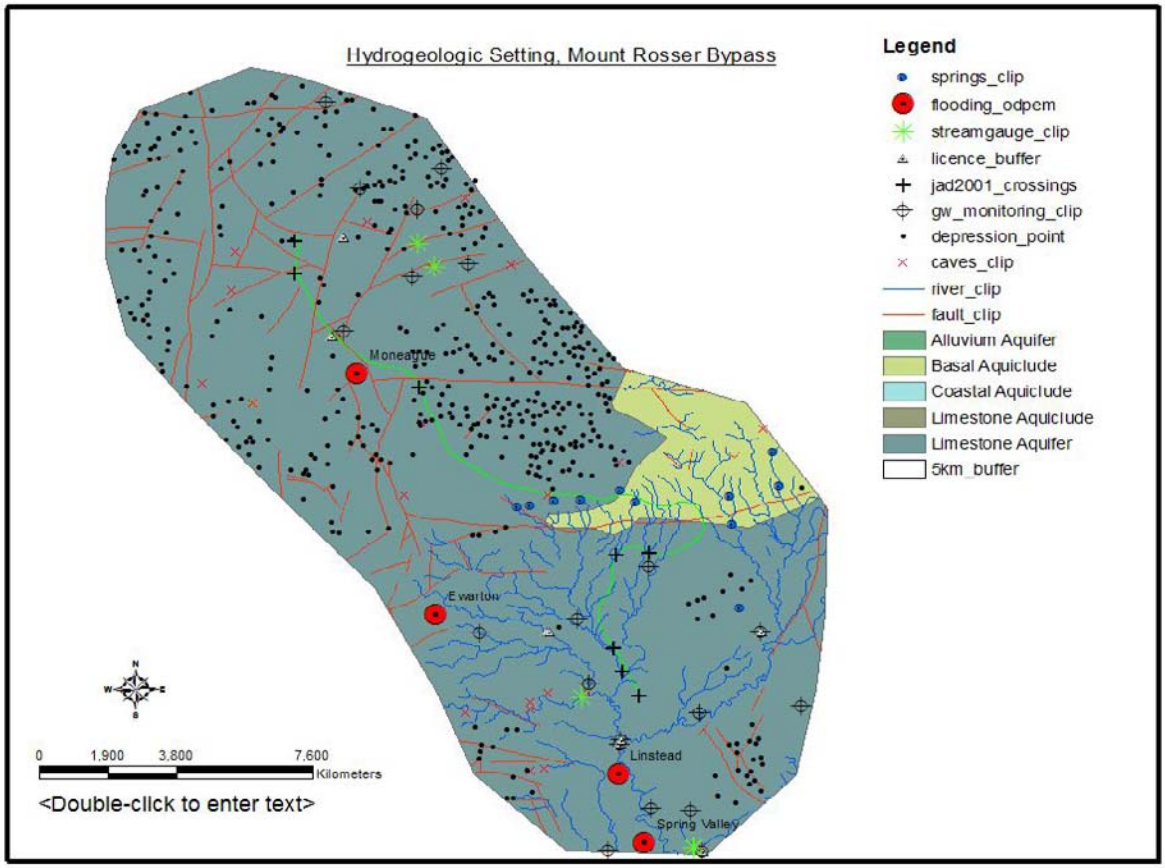
• Table 2 - Anticipated water crossing, structure type and ultimate discharge basin

The alignment crosses the limestone aquifer (tertiary limestone) and basal aquiclude (volcaniclastics) as shown in Figure 3. The recharge area for the limestone aquifer is located within the Mount Zion, north of the med-section of the alignment. The presence of numerous sinkoles/depressions supports this recharge zone. Principal groundwater direction is northwards with groundwater gradients between 0.01 to 0.04[ii].

Several springs are noted in Figure 3 and their line of outcrop roughly follows the geological boundary between the Cretaceous volcaniclastics and the Tertiary limestones. Their presence suggest on the surface that rainfall impinging on sections of the Mount Zion catchment possibly percolate and discharge to the south and become emergent along the aquifer/aquiclude boundary. Some of these springs are developed for public and domestic water supply purposes. The alignment passes within 100 – 190 m of the Recess, Mountain Pass, Bermaddy and Mullock springs between km10+000 and 13+000.

One groundwater well (Unity Valley at 237962 mE and 177798 mN) is located within 100m west of the alignment (circa km 21+000). Its pumping rate is recorded as 1091 m^3/d. Given its proximity it may fall within the RoW of the alignment. The well is registered to Glencore Alumina Jamaica.

Figure 3 shows other features within 5 km buffer along the specific points (JAD2001 crosses) on the alignment.



• Figure 3: Hydrogeological Setting Mount Rosser Bypass

7.1.4 Geology, Topography and soil

Published geological information (extracts of Sheet 18 and 19 shown in (Figure 2, Appendix VII) indicates the solid geology of the site comprises Mid-Eocene to Oligocene members of the White Limestone Group. The Newport Formation, comprising recrystallized bioclastic limestone with patches of chalky "marl", dominates from the km0+000 to around Recess/Mango Grove. And as the highway curves west it crosses the Mount Diablo Fault and the dominant outcropping limestone, after Baileys Town changes to the older Walderston-Browns Town Formation, on which the Newport Fm. Conformably rests. The Walderston-Brown's Town Fm represents two separate limestone facies – The Walderston and Brown's Town facies. The Walderston facies outcrops predominantly within the alignment corridor. It comprises a buff-white, compact,

partly re-crystallised, micrograined limestone dominated with microspar. The Brown's Town formation is described as a rubbly, patch reef limestone to bedded pink microsparite. The oldest rocks of the White Limestone Group, the Swanswick Formation, outcrops only around the western extension of the Benbow Inlier north of Bermaddy, where it lies directly on the lower unit of the Devils Racecourse Formation. It comprises well sort calcarenites and abundant algal and shell fragments.

Several caves are also know to occur in close proximity to the alignment. The closest, the Potato Hill cave chamber (244,000 mE, 173,000 mN) is about 40m south of the alignment at km 12+000. Its elevation is 460 masl and around 36m in length, no depth was recorded. The second is the Schwallenberg Cave (240,500mE, 175,000mN) located 350m west of km 16+500. The cave is located at an altitude of 470 masl and is described as a cave leading to a shaft; it has a recorded explored depth of 76m and is 73m in length. Figure 3 shows the locations of the caves which was based on the published book "Jamaica Underground" by Allan Fincham publication.[iii]

As the alignment curves at Mango Walk and continues by Bailey Town it crosses onto the Cretaceous rocks of the Devils Racecourse Volcanic Formation, an inlier. This formation consists generally of lavas and volcaniclastics with interbedded limestone. The formation that is principally found around Baileys Town is the lower unit and is comprised essentially of flow banded lavas overlain by poorly bedded epiclastic volcanic conglomerates. The rocks have also undergone regional metamorphism and hydrothermal metamorphism.

The Alluvium deposits are present along the Byndloss Gullies and consist of a mixture of terra rossa (bauxitic soils) and transported gravel, sand and clay from the Cretaceous Inlier (Benbow Inlier) to the north. Thickness is irregular but will principally deeper along the middle of the gully channel and taper towards the ends.

The soil profile across the alignment is presented in Figure 4, Appendix VII and comprises mainly clay loams a few metres thick.

Structurally, the Mount Diablo Fault that runs E-W just above Recess and south of the Benbow Inlier that the alignment traverses. The fault is considered to be pre-Tertiary in age and have since been rejuvenated. The Benbow Inlier is as a result of folding and is due to a NW-SE anticline. An anticline is usually recognized by a sequence of rock layers that get progressively

older toward the centre of the fold because the uplifted core of the fold is preferentially eroded to a deeper stratigraphic level relative to the topographically lower flanks. The strata dip typically away from the crest of the fold. This older crest is exposed north of Baileys Town.

Ancient landslides, or slumps, have been noted on the geological sheets. They are mapped west of Ewarton where Tertiary Rocks (limestone) have slipped over basal Cretaceous rocks (see geological map).

Geotechnical Classification

Alluvium: deposits extremely variable vertically and laterally, excessive differential settlement and high erodability. The presumed bearing capacity ranges between moderate to low (40 – 700 KN/m^2). Slope stability is highly dependent on in-situ soil strength, particularly cohesion.

Newport Limestone Formation: in the exposures along the route are more variable ranging from soft to nodular chalks to recrystallised limestones. Soil development is minor or thin in mountainous areas and considerably thicker fills in depressions and low-lying regions. Bearing capacity is presumed to be good (1000 – 4000 KN/m^2). Karstic drainage features such as solution features (sinkholes) are present and checks need to be done for such structures wherever major structures will be placed. Flooding of these depressions and gully courses are listed amount the possible construction problems. Slope stability is generally good but landslip risk increases along faults and rock falls should be anticipated.

Swanswick Formation: generally similar in character as per the Newport Formation.

Walderston-Browns Town Formation: generally similar in character to the Newport Formation, but are generally softer and less competent. Hard rubbly limestones generally associated with fault zones. Large and continuing rock falls should be anticipated along fault scarps. Landslip risk is increase along fault scarps, such as the Mount Diablo Fault. Depth to bedrock is extremely variable. Karstic depressions are common and can be fault controlled. Increased flood risk in depressions and gully courses.

Devils Race Course Volcanic Formation: Generally hard and well cemented. Where the rock is competent minor rock falls can occur in vertical cut slopes. In fault zones the rocks can be highly

fragmented and consequently there is an increased risk of rock falls. When soil cover is deep rotational type failures should be anticipated. Presumed bearing capacity id dependent on competency of the outcrop and varies from 2,000 – 10,000 KN/m^2 for sound rock and 500 – 2000 KN/m^2 depending on the degree of weathering encountered. Overlying clay soils susceptible to swelling.

7.1.5 Stormwater Runoff

The assessment below uses the Rational Method to evaluate major and minor drainage pathways that cross the alignment. The assessment then compares this anticipated, pre-highway runoff with the anticipated road surface runoff combined with the pre-highway figures. Drainage ditches from Design for Approval (DFA) drawings were used to quantify the actual 100m lengths of the alignment discharging to each natural drainage outlet. This runoff from a typical 100m section was then multiplied by a factor based on the number of 100m sections draining to the discharge outlet. This "new" water was then compared to the pre-existing condition to evaluate whether the additional runoff from the highway would be significant or acceptable using the 1:25 yr rainfall intensity figures.

Catchments and drainage pathways were visually defined using, 1:12,500 topographic maps, and balanced with aerial photographs and digital elevation data held within the Google Earth database. Due to the presence of caves and sink holes in many locations, the delimitation of the drainage basins using only this information must be validated with in-situ observations and site inspection. These will be carried out in the detailed final designs as the EIA is not a design document but a platform to evaluate preliminary designs. Significant differences can be observed between the visual/topographic delimitation and the actual limits of the drainage system. Consequently, a thorough site inspection at each identified crossing site and a critical hydraulic analysis of the existing dry-gully cross-section will also be required by the design engineers in assessing the validity of their discharge evaluation in terms of actual evidence of observed/measured vs calculated stream conveyance. This assessment relies strictly on visual/topographic information and the cognitive uncertainty (bias) must be appreciated.

The Rational equation was developed from a simplified analysis of runoff. The method assumes no temporary storage in the basin, so the ratio between the peak runoff and the rainfall intensity is then the same as the ratio of the volumes of runoff and rainfall. If a constant rainfall intensity (mm/hr) begins at time t=0 and has a duration of the time of concentration (t_c) for the basin, the hydrograph will reach an instantaneous peak at Ci. The t_c of the basin can be thought of as the time after rainfall excess begins to when all portions of the watershed are contributing to the peak flow at the outlet. If the duration is longer than t_c, the hydrograph will remain constant after reaching a value of Ci for a time period equal to the difference of the rainfall duration and t_c. In either case the time of rise and time of recession are equal to t_c. The Rational Equation is defined:

Q = kCiA

where:

- Q - peak flow (cfs or m^3/s).
- k - conversion factor equal to 1.008 (SI) or .00278 (metric).
- C - dimensionless runoff coefficient.
- i - rainfall intensity (in/hr, mm/hr).
- A - catchment area (acres, ha).

Time of concentration is a fundamental watershed parameter. It is used to compute the peak discharge for a watershed. The peak discharge is a function of the rainfall intensity, which is based on the time of concentration. Time of concentration is the longest time required for a particle to travel from the watershed divide to the watershed outlet. The time of concentration was determined for the alignment using the FAA method:

$$t_c = 1.8\,(1.1 - C)\,L^{0.5} / S^{0.33}$$

Where

C = Rational method runoff coefficient. *As a conservative approach values for the runoff coefficient C used in the rational method should not be less than 0.35 for a return period of 25 year and 0.45 for 100 year, even for rural areas. For completely paved areas, the coefficient is 0.9, whereas for urbanized areas well drained with sewer networks and canal, it should not be less than 0.6.*;

L = Longest watercourse length in the watershed, ft

S = Average slope of the watercourse, unitless.

Intensity values were obtained from an intensity-duration-frequency (IDF) regression equations developed in Section 3.4.5 and presented by catchment in Appendix 6 of Drainage and Hydrology Report Vol. II of the SEA (2000).

The rainfall intensity for the alignment catchments based on the calculated t_c is as follows:

Natural Catchment Area

ID	Km	Name	Catchment Area *sq. miles*	Appropriate IDF Equation	t_c Rainfall intensity (mm/hr)		
					1:10yr	1:25yr	1:100yr
1	3+340	River (Byndloss Gully)	0.07	Segment E	157	206	261
2	5+600	River (Byndloss Gully)	0.320	Segment E	137	180	228
3	0+750	River (tributary of Byndloss Gully)	3.30	Segment E	118	156	198
4	6+265	River (tributary of Byndloss Gully)	0.45	Segment E	159	209	265
Typical Road Section				Segment C			
Typical section	n/a	Represents 100m of aligment	0.00097		363	467	591

Rainfall Intensity
Bushy Park to Ocho Rios

Segment E

It was assumed that 100m of highway on either side of these water crossings is collected and added to these discharge points.

In general terms, the rate and volume of surface water runoff from the post-development situation should not exceed the surface water runoff from the existing site. An increase of 5-10% is normally deemed acceptable. Overall the appraisal suggests that drainage should not be a significant problem at most of the water crossings post-highway with the exception of km3+340. It must be highlighted that the size of the culvert is sufficient to handle the predicted flows. The post-development figures only indicate the sensitivity of the pathway to any additional water input and not reflective of an adverse condition on the ground.

7.1.6 Drainage Assessment

Drainage and Stormwater Management

The drainage system will be designed to accommodate Jamaican climatic conditions, comprising heavy rainfall and rapid runoff, through a system of drainage with two components:

- The minor drainage system, which will collect runoff resulting from the more frequent storm events and will be designed to convey the runoff to the outlet

at the receiving major drainage system. The minor drainage system will consist of kerbs, channels, storm sewers, small cross-culverts and roadside ditches.

- The major drainage system consists of the large existing gullies and rivers, which take and discharge the runoff from the minor drainage system.

Crossings will be designed to comply with the recommended average number of 2.6 per km and will be designed with a minimum diameter of 900 mm. Ditches will be of a trapezoidal design and their size will be consistent with the calculated flow to be accommodated. In general, all ditches will be lined, where their longitudinal gradient is greater than 3% or where in-situ material is likely to scour), with concrete, rip rap, grouted stone, or precast concrete elements.

Generally, the 3.6 m wide median will slope away from the barrier but, where the road is super-elevated and the paved surface slopes toward the median, a system of prefabricated channels shall be installed alongside the median barrier with longitudinal pipes discharging transversely at intervals to the outside of the carriageway.

Drainage pathway and hydrogeology considerations along the alignment

These considerations discussed below are highlighted in Figure 3 above and obtained from the 1:12,500 topographic maps, aerial photographs and geological maps along the alignment.

- Km 0+750 – 0+800 the alignment crosses a tributary of the Byndloss Gully drainage system. Arial photographs indicate the presence of a dry drainage pathway that is linked to the upper catchment of the Byndloss catchment. This is supported by the 1:12,500 topographic maps and ground evidence of hydraulic flows. A bridge is not indicated at the crossing and it would be recommended that this be revisited and consideration be given to a similar type structure as at km 3+340. Calculations of the potential 1:25 and 1:100 yr peak flows are given in the sections below.

- Km 6+265 (approximate): A drainage pathway from the upper catchment of the Byndloss system parallels the A2 road 45m east. The alignment Layout

Plan dated 21.05.07 (1st issue) indicates that it crosses this drainage pathway east of the road. Given that the Byndloss Gully is known to take runoff it would be recommended that the drainage pathway be included within the final design. Possibly a single crossing that includes the field connector at km 6+220 could be considered. Anticipated flows for 1:25 and 1:100yr are given below.

- Km 7+000: in the vicinity of this chainage a depression/sinkhole is noted on the 1:12,500 topographic maps. The alignment passes within 50m of the eastern edge of the depression and maybe within the alignments RoW. As depressions/sinkholes are integral to the drainage systems in Jamaica consideration should be given to ensuring that the depression is not filled or extensively modified as this could lead to changes in the drainage characteristics of the immediate area.

- Km 8+000 to 14+000: As the alignment traverses the volcanics of the Devil's Racecourse Formation the expression of more surface drainage lines are evident. At least ten surface drainage pathways intersect the alignment. The largest catchment is approximately 0.2 km^2. Estimates of runoff are given below:

- Km 14+000 to 18+000: The alignment re-emerges on limestone. Surface drainage expressions are immediately absent, however, depressions/sinkholes and cave chamber become more dominant during this section. The alignment passes 40m north of Potato Hill Cave (244000mE, 173000mN) at km12+000, then through several depressions /sinkholes around km17+000. Several of these depressions are possible linked to mined bauxite depressions, however, the presence of the Schwhallenberg Cave in the vicinity suggest that some of the depression, are likely to be associated with karst solution features. Consequently, outright filling of these depressions may adversely modify the surface drainage which may lead to unintentional flooding. It is understood

that the contractor will ensure that no unintended flooding will occur due to the development of the highway.

- Km 21+000: About 500m east or west of this chainage, in the vicinity of Unity Valley, the alignment crosses the southern most probable extent of the Moneague Groundwater Lake. Section 2 above described the mechanics behind the prevalence of groundwater surface emergence in these low-lying zones. Given that this area has flooded in the past due to groundwater emergence after sustained heavy rainfall, reasonable engineering consideration needs to be given to ensure that during such a future event the risk of pavement failure due to increased pore-water pressures in the sub-base is managed. Mitigation measures such as underdrains should be considered in these areas.

- Km 23+000 to 23+200: the alignment crosses the eastern limb of the Moneague Groundwater Lake, based on 1810 estimates. Mitigation
- measures, such as underdrains, may be a suitable mitigation features.

The original Outline Design anticipates the following water crossings;

Km	Type	Crossing
3+340	River	Underpass
5+600	River	Underpass

However, based on the forgoing these possible minor crossings are anticipated;

Ref	Km	Type
-	0+750	River (tributary of Byndloss Gully)
-	6+265	River (tributary of Byndloss Gully)

Other probable minor drainage crossings that require further evaluation are;

Between 8+000 to 14+000	Minor drainage features

Appendix VIII shows the catchment delineations for four main drainage pathways and flow calculations.

Outline of the Hydraulic Design Criteria used by the Design Engineers

The minor storm sewers on arterial roadways are to be designed to convey the 10-year storm without exceeding capacity (surcharge) and to pass the 100-year storm via the overland system (major drainage) with maximum permissible flooding of 300 mm above roadway surfaces, without affecting the highway. The roadside ditch system will also be designed with the 10-year storm and freeboard, as measured from the edge of through traffic lanes to the design high water level in the ditches, should not be less than 1.0 m for the 100-year storm. Flow velocities will be checked for erosion and scour for 100-year events, with appropriate scour protection measures provided as necessary.

The major drainage system must provide a continuous overland route for the parts of the runoff produced by the 100-year runoff event The system will be checked to ensure that it is not inadvertently cut off by highway profiles and that it can convey the major storm (100-year) without affecting the highway. Overflow routes from road drains to the receiving system will be provided to ensure that water does not pond to excessive depths (> 300 mm) on the highway surface for the 100-year event. The major drainage system will also be checked to prevent undue hazards to the public and damage to property adjacent to, and downstream, the highway.

As for the hydraulic criteria for the water crossings, Highway 2000 is to be designed to operate satisfactorily under the severe weather conditions of a **100-year storm**. All bridges and culverts over 5.0 metres in total opening width are to be designed to pass the 100 year storm with a minimum freeboard of 1.0 m between the lowest point of the bridge (soffit) and the high water level. Culverts of under 5.0 metres in total opening width are to pass a 25-year storm without surcharge and to provide a minimum of 600 mm of freeboard between the edge of road and the high water level during a 100-year storm event.

Different approaches will be used by the design engineers to determine the design flows at each drainage crossing, as given in the following table:

Method	Assumptions	Data Required
Rational	Small catchment (<1.3km^2) Concentration Time <1 hour Storm Duration> or =Concentration Time Rainfall is primarily overland flow Negligible Channel Storage	Time of Concentration Drainage Area Runoff Coefficient Rainfall Intensity
NRCS (TR55)	Small or Mid-Size Catchment (<8km^2) Concentration Time from 0.1 to 10 hours(tabular hydro graph method limit <2 hours) Runoff is overland and Channel Flow Simplified Channel Routing Negligible Channel Storage	24 hour rainfall Rainfall Distribution Runoff Curve No. Concentration Time Drainage Area
NRCS (TR20)		24 hour rainfall Rainfall Distribution Runoff Curve No. Concentration Time Drainage Area
Unit Hydrograph (Gauged Data) NRCS Unit Hydrograph Synthetic Unit Hydrograph	Midsize or large Catchment (0.4-2500 km^2) Uniformity of Rainfall Intensity and Duration Rainfall/Runoff relationship is linear Duration of direct runoff constant for all uniform/intensity storms of same duration regardless of differences in total volume of direct runoff Time distribution of direct runoff from a given storm duration is independent of concurrent runoff from preceding storms Channel routing techniques used to connect streamflows	Rainfall Hyetograph and direct runoff Hydrograph Drainage area and lengths along main channel to point on watershed divide and opposite watershed and opposite centroid (Synthetic Unit Hydrograph)

Explorative Drainage Assessment

The explorative drainage assessment looks to:

1) Determine and describe how stormwater will be disposed of both during construction and site operation;

2) Determine the environmental impacts of discharges of stormwater and the suitability of proposed mitigation measures; and,

3) Determine the suitability of the proposed options for both construction and operation phases particularly on the open canals to the southeast of the site.

Drainage Control during Construction

During construction, features such as, site access, storage of materials, site drainage during construction and protection of surfaces from erosion, sedimentation and over compaction require particular attention. To achieve a balance, construction planning has to incorporate erosion and sediment control measures together with the need for maintenance inspections. However, in Jamaica construction practices and general workmanship have made implementation of such measures difficult as it is not the norm for contractors to consider such activities. This makes their implementation and maintenance that much more difficult on any construction site due to unfamiliarity and the inherent difficulty in modifying human behaviour without appropriate punitive sanctions levied by the regulatory agencies.

Notwithstanding the foregoing, the alignment crosses several streams, dry gullies and gullies and rivers so erosion and sediment control will be of paramount importance during construction in order to reduce discharges to these water courses. In order to mitigate any deleterious impact the following guidelines are recommended in developing the erosion and sediment control plans:

- Determine the extents of clearing and grading along the alignment. This has been evaluated in the cut-and-fill budget.
- Determine temporal and permanent drainage features/pathways and define the limits of roads and drainage catchments.
- Determine the extent of any temporary channel diversion for the existing drainage features.
- Determine suitable sediment controls by investigating the requirements of each drainage sub-catchment. This would assist considerably in the reduction of final discharge volumes and flow velocity.
- Determine the staging of construction with a view to minimising the period of exposure of exposed open ground.
- Identify locations for topsoil or aggregate stockpiles and temporary construction roads and site camps.

- Select erosion controls based on the duration of soil exposure and the characteristics of its sub-catchment. These can be selected based on the construction programme.

- Consideration should be given to the potential water level rise within the existing drainage features during construction due to heavy rainfall events during the lifespan of the construction. Options such as the construction of temporary earthen berms or similar grade elevating devices should be considered.

- Any groundwater wells that need to be relocated will have to be done by well drilling contractors. Any existing well that will require closure will need to be grouted with bentonite/cement slurry from base to surface and sealed with a 100mm thick concrete pad extending 300m beyond the diameter of the well.

The objectives of the erosion controls during construction should:

- Limit or reduce soil erosion, sediment movement and deposition to water bodies of all land disturbing activities.

- Seek to establish temporary or permanent cover as soon as possible after final grading has been completed. Surface stabilisation should be considered for areas not at final grade which may remain undisturbed for more than 30 days. Given that Jamaica is prone to short intense rainfall events, especially in the afternoon, consideration should be given to controlling sediment movement through temporary covers, silt fences, and diversion ditches for areas within 30m of a water body.

- Design all temporary and permanent facilities for the conveyance of water from disturbed areas at non-erosive velocities.

Road construction will intensify the effects of natural soil erosion due to vegetation removal, soil disturbance, and exposure of bare soil surface. The most severe problems will be associated with embankment construction in the plain area, road sections with heavy cuts and fills, borrow and

spoil sites, as well as bridge and culvert construction sites, particularly on rainy days. If appropriate measures are not taken, the increased erosion loss could be significant over the construction period.

Erosion and Sediment Control techniques that should be considered are:

- Routing runoff through existing vegetation to control sediments and reduce downstream velocities. Manage vegetation clearance in a manner that preserves pockets of existing vegetation for use as vegetative control devices post-construction.

- Install gravel diversion trenches (French drains) upstream of exposed land, bearing in mind that depth to groundwater may limit vertical depth.

- Temporary sediment traps/basins to reduce velocities.

- Silt basins will be used, where appropriate, to intercept water runoff and allow solid matter to settle before entering gullies and river courses. After completion of road construction these basins will be graded and revegetated. Installation of settling basins at bridge and interchange construction sites to collect sediment from construction wastewater before its discharge; appropriate disposal of removed sediment and spoils from drilling operations at the bridge construction sites should be considered.

- Silt dikes and runoff ditches will be installed where appropriate to prevent silt from leaving sensitive areas (borrow sites, spoil sites, etc.) and entering farmland or water bodies.

- Temporary groundcover (matting, grass bales, sandbags, etc.) will be used on disturbed and exposed areas to control erosion and retard runoff, particularly during rainy periods. Geotextiles and erosion control fabrics in difficult areas. Such as fractured slopes or slopes with thin erodible soils.

- Provide construction and site camp roads with stabilisation comprising stones/sand bags etc. immediately after grading to prevent erosion during wet

weather due to vehicular traffic and to reduce the need for regrading for permanent roadbeds between initial and final stabilisation.

Drainage Control during Operation

Drainage control during operation for all phases of Highway 2000, is to be designed to operate satisfactorily under the severe weather conditions of a 100-year storm. All bridges and culverts over 5.0 metres in total opening width are to be designed to pass the 100 year storm with a minimum freeboard of 1.0 m between the lowest point of the bridge (soffit) and the 100-yr high water level. Culverts of under 5.0 metres in total opening width are to pass a 25-year storm without surcharge (overload) and to provide a minimum of 600 mm of freeboard between the edge of road and the high water level during a 100-year storm event.

Development of the surface drainage during operation works is a two-tier system. First, the minor drainage system collects runoff that results from the more frequent storm events and conveys the runoff to the outlet at the receiving system. The minor drainage system usually consists of curbs, gutters, catch basin inlets, storm sewers, minor swales and roadside ditches. The major drainage system is the route that is followed by runoff when the capacity of the minor drainage system is exceeded.

The minor storm sewers on arterial roadways are to be designed to convey the 10-year storm without surcharge and to pass the 100-year storm via the overland system (major drainage) with maximum permissible flooding of 300 mm above roadway surfaces, without affecting the highway. The roadside ditch system will also be designed with the 10 year storm and freeboard, as measured from the edge of through traffic lanes to the design high water level in the ditches, should not be less than 1.0 m for the 100 year storm. Velocities should be checked for erosion and scour for 100-year events, with appropriate scour protection measures provided as necessary.

The major drainage system must provide a continuous overland route for the parts of the runoff produced by the100-year runoff event that cannot be conveyed by the minor drainage system. The system should be checked to ensure that it is not inadvertently cut off by alignment profiles and that it can convey the major storm (100-year) without affecting the highway. Overflow routes from road sags to the receiving system must be provided to ensure that water does not

pond to excessive depths (> 300 mm) on the highway surface for the 100-year event. The major drainage system will be checked to prevent undue hazards to the public and damage to property adjacent to the highway.

Finally, if the discharge from a surface drainage system is likely to significantly increase erosion in the receiving system, consideration should be given to protecting the water course through the application of in stream erosion control measures.

All outfalls to receiving systems will have scour-protection using gabion mattresses or rip-rap.[iv] Trash screens will also be installed were appropriate to reduce off-site conveyance of garbage.

Measures to mitigate against flooding (holding ponds) should be adopted where necessary, in accordance with Concessionaires Specifications to reduce the volumes to these systems on downstream interests.

Pollution Control Measures during Operation

Pollution control measures are likely to include a mix of the following:

- Trash Screens to prevent large detritus from entering system and cause blockages. Routine maintenance will be incorporated.
- Oil/water interceptors should be installed on the primary minor drainage systems that discharge to any water courses/gully or stream, in order to minimise hydrocarbon discharge to water course. Additionally these minor drainage systems will collect hydrocarbon runoff after collisions before they reach the secondary larger drainage system. It is unlikely that the larger, secondary drainage system will require oil/water separators.
- Catchpit manholes may be installed to provide areas of sediment control and flow controls were the available ROW is restricted in width and swales cannot be reasonably installed.
- Wash-out chambers will be installed to enable cleaning and maintenance
- Reed beds for polishing of discharge at outfalls via the reduction of hydrocarbons and sediment loads will be considered for perennial water courses and were practicable to do so. The longitudinal ditches which flank

the highway should also be considered at as polishing areas prior to discharge to perennial water courses.

- No water discharge shall be made to any sinkhole or depression.
- Planting on the verges to reduce soil erosion and suspended matter being carried in the run-off.
- Closed drains shall be used in areas where aquifer vulnerability is considered as high. As the alignment traverses one of the more productive limestone aquifers, it is considered a high value aquifer. As the geotechnical study has shown that overburden depths can be shallow or bedrock at surface, areas with less than 1m cover or exposed bedrock would be considered as high vulnerability areas. In any such area where, after final graded levels, the limestone is covered by less than 1.5m of natural slow draining soils or there is exposed limestone then closed drains should be incorporated.

Appendix IX presents the EXCEL/Crystal Ball reports for the reports used in this chapter.

7.1.7 Natural Hazards Risks

7.1.7.1 Flooding

Historic Flooding in the vicinity of the proposed route

Flooding historically has not been significant problem within the southern and mid-sections of the alignment, however, the northern section has records of historic flooding at the Moneague and Tadmore groundwater lakes since 1810. Flooding here is a combination of geology (sinkholes/depressions), intense rainfall and topography. Flooding events are recorded in Jamaica by the ODPEM and normally these reports are linked to populated areas. So there is a natural bias in the data towards more reports in populated areas as opposed to sparsely or non-populated areas as expected. Additionally, public perception of flood events within their lifespan biases them to overestimate the occurrence of such events and in Jamaica they seem to link them mentally to recent large-scale infrastructural developments within their environs.

In order to address these likely concerns this section will discuss the past flooding event at Moneague in some detail to ensure that the appropriate appreciation for there causes are established. The section will look at the localised flood events, as recorded by the ODPEM and via discussion with residents, and then look in detail at recurring Moneague flood.

ODPEM Flood Registry and local flood appreciation

The ODPEM database compiles flood events in populated areas. The Figure 3 above and Table 4 below shows records held by the WRA for flood events recorded by the ODPEM within 1000m of the alignment. Of the three events, only the Moneague event is within 1000m south of km 19+500. No date was recorded or extent given.

Residents in the following communities were queried and their perceptions of flooding in their communities are summarized below in Table 3.

Community	Number of persons interviewed	Main findings	Comment
Byndloss	24	Flooding dependent on state of drains. No outright flooding during short periods of heavy rain. Flooding occurs after about 2 or 3 days of continuous rain. 63% stated that flooding in the community was not a problem.	Flooding is not a normal problem for Byndloss and only occurs with very intense rain fall. It is likely that when this occurs it is the drainage infrastructure that is overwhelmed.
Charlemont Farm Scheme (Not to be confused with Charlemont Housing Scheme)	32	Reported as a flood prone area, but mainly on the western side i.e. towards the housing scheme. All respondents reported that flooding is a problem, but similarly all reported the flooding to occur mainly closer to the housing scheme. York Street and Russel Pen mentioned specifically. Some respondents attributed flooding to the Byndloss Gully overtopping, but this needs to be confirmed.	The community reports flooding to be a problem. But attributed is to road profile and grade and blocked rains.
Treadways	21	All respondents reported that flooding is not a problem in this area.	Flooding is not a problem for this community as surface water drains immediately without

Community	Number of persons interviewed	Main findings	Comment
			ponding.
Mountain Pass	11	All respondents reported that flooding is not a problem in this area.	Flooding is not a problem for this community.
Faith's Pen (The rest stop)	29	With the exception of 9 respondents all others reported that flooding was not a problem. Those reporting that flooding was a problem, qualified this by saying it was "sometimes".	Flooding is not a problem for this community.
Moneague	20	In the town section flooding was reported as not being a problem. 4 respondents indicated that flooding occurred by the Riverhead Spring and wetland area close to the school.	Flooding is not a problem for this community in the vicinity of the town.

• Table 3 - Flooding perception in some communities surrounding the alignment

Reoccurring Moneague Flooding

This section is based on the WRA's in-house reports and presentations on the science behind the most recent flooding event in 2005. The complete reports are included in Appendix IX.

The first recorded flooding event at Moneague was recorded in the Daily Gleaner in 1810 where it was reported that > 10.5 km^2 (>4 mi^2) of land was inundated. The groundwater lake destroyed property that the Vestry (Property Tax collector at the time) gave relief to land owners via a land tax amnesty. The WRA table (reproduced below) describes the 12 flooding events over the past 195 years as the available data allows. The majority of these reports have been obtained from the Daily Gleaner's Archives.

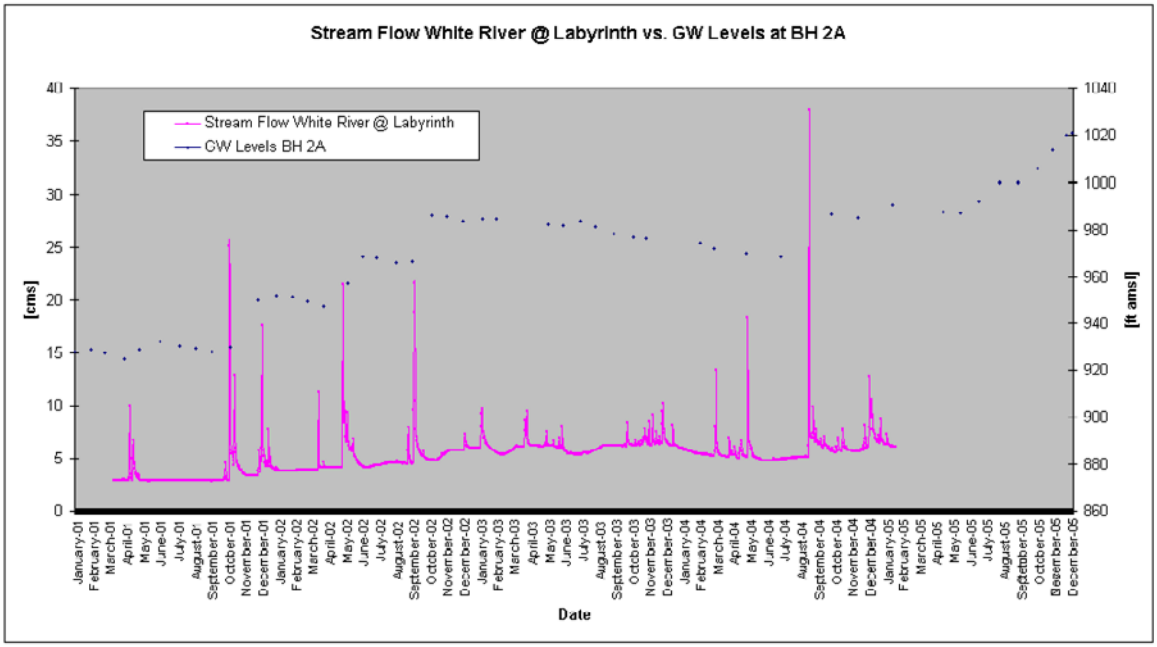
Year of Rise	Annual Rainfall (mm)	Lake Life (years)	Impact
1810			>4 mi² covered
1863			>1 mi² covered
1874			<1863 Lake
1886	2794		
1916	3,205	3	>0.7 mi², 8 houses covered, 2 lives lost
1933	3,582	>3	0.8 mi² (500 acres), 18 houses covered, 1 life lost
1963			
1970			
1974		>3	
1988			
2002			
2005-	3,398 (in 2005)	Still rising	0.70 mi², 12 houses covered 2 lives lost

• Table 4 - Historic groundwater lakes as recorded by the WRA

The Moneague and Tadmore lakes are groundwater surface expressions and occur due to geology/hydrogeology, topography and intense and sustained rainfall. The limestone formation, that underlies the majority of the bypass, is part of a larger limestone aquifer that extends from Moneague to the north coast. Numerous sinkholes in the Mount Zion plateau provide recharge to this aquifer via deeper interconnected solution conduits that ultimately discharge along the north coast. The hydrogeology is quite complex as suggested by work done by Michael Day in 1976 on similar geology west of the site. In this study dye tracers were released within depressions in the recharge sinkholes and dye breakthrough observed within several groundwaters fed river systems. Breakthrough times indicated flow rates between 250 to 500 m/day with observances across river systems indicating a complex interconnection of subsurface conduits.

Topographically, the Moneague and Tadmore lakes occupy land areas that average about 305m asl (1000 ft asl) and is surrounded by limestone hills. As the limestone aquifer recharges due to

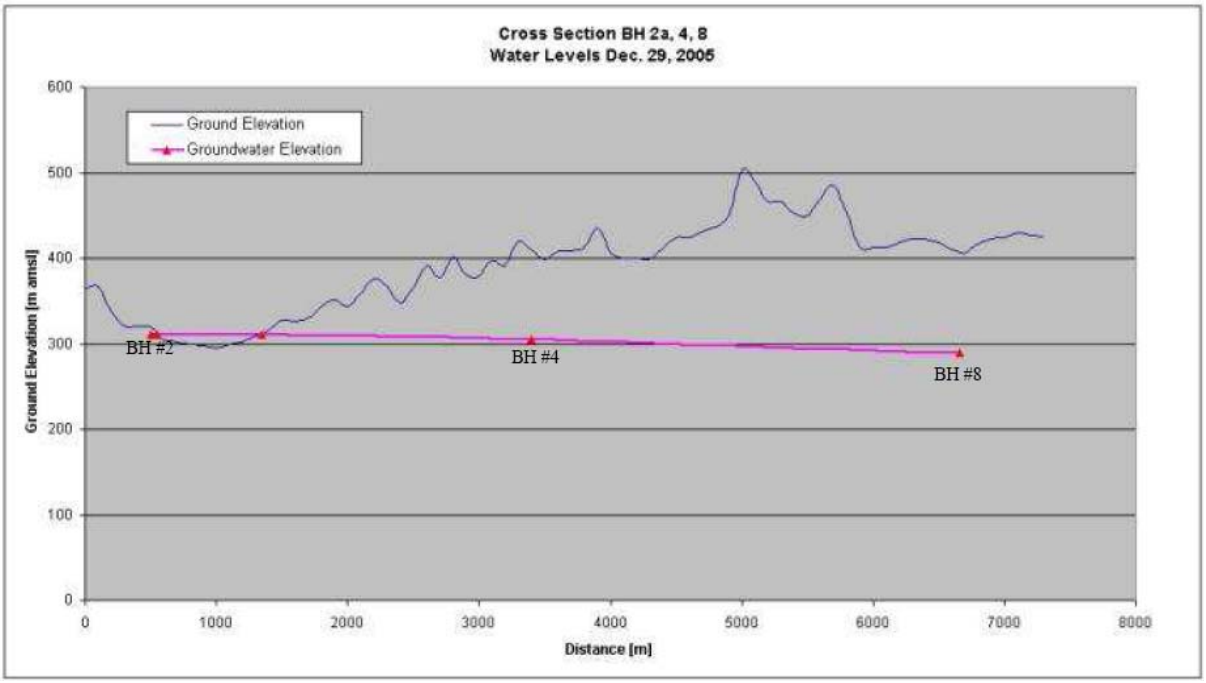
rainfall the groundwater table rises. The WRA suggests that an annual threshold rainfall of 2880mm is sufficient to trigger groundwater surface emergence. From the records the 1916, 1933 and 2005 Moneague flooding events all had annual rainfall totals of over 3200 mm. This annual exceedance figure is the cumulative result of several events during the year and it is these events of short duration (days to weeks) that push the annual totals above average values. It should therefore be appreciated that groundwater floods are the results of these short-lived but intense rainfall events which are strongly dependent on antecedent conditions. To demonstrate this a comparison of Groundwater and Stream hydrographs from the White River at Labyrinth and BH2A at Rio Hoe (Figure 5 below) suggests that groundwater levels rise immediately following rainfall events between April to May and August to October peak and are sustained for several months before declining. This remarkable graph shows the cumulative effect of several rainfall events progressively increasing the groundwater levels within the aquifer until it increases above 305m and results in groundwater expression in the low lying areas. Rainfall in May 2005 and associated with Hurricane Wilma in October 2005 were the rainfall events that pushed the antecedent conditions to critical in the Moneague area. These hydrologic events are not represented in the stream flow hydrograph but are noted on the groundwater hydrograph.



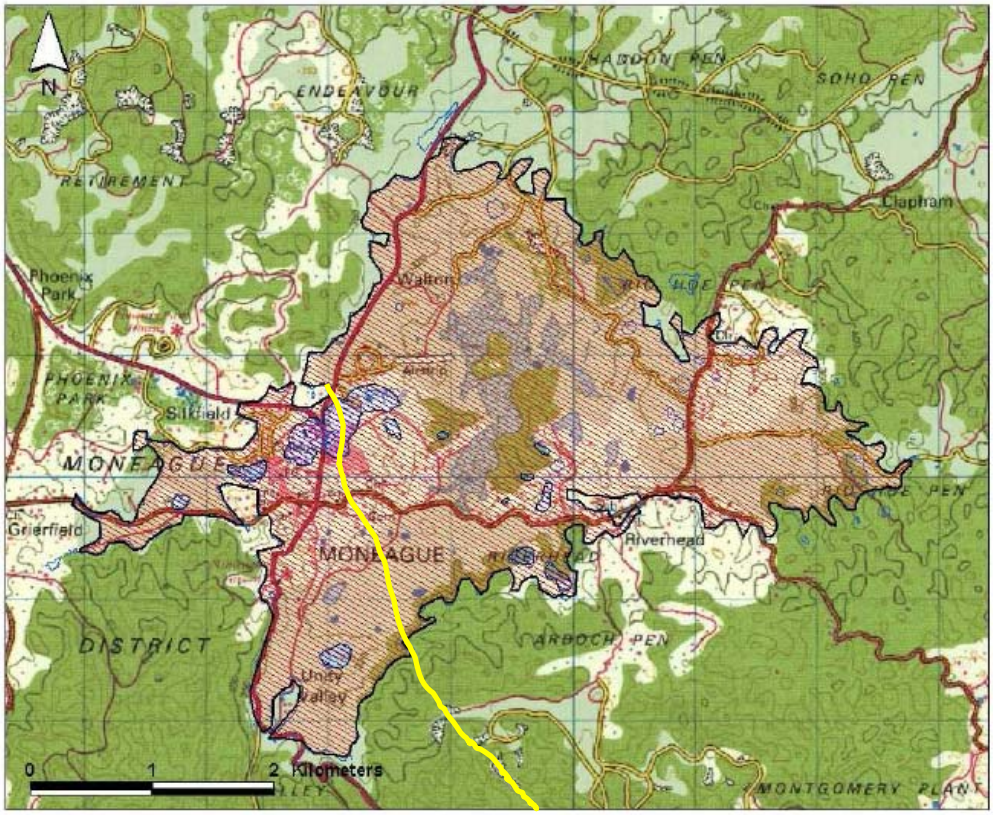
• Figure 5 – Hydrograph comparison of the White River stream gauge and groundwater levels at Rio Hoe.

Figure 6 (below) shows groundwater profiles as of December 29, 2005 through the same borehole at Rio Hoe (BH#2A) shows the static groundwater level above the 300m ground level mark. The 2005 event covered 168 hectares and 49 hectares in Moneague and Tadmore lakes respectively. The maximum submerged water depth in the Moneague Lake was 12.5m indicating that approximately 20 Mm^3 of water was detained in the lake. Riverhead main road was submerged up to 7.5m. The WRA estimated that the rate of rise in groundwater at approximately 3 cm/day. The rate of decline was estimated at an order of magnitude less at 0.3 cm/day.

Figure 7 (below) is the WRA's interpretation of the complete spatial extent of the Moneague Groundwater Lake. Its borders typically follow the 300m contour and covers approximately 1214 hectares (3000 acres or 4.7 $miles^2$). Only in 1810 was the full extent of the lake revealed, where >1000 hectares was reported as being flooded. Events since 1810 have only extended less than 260 hectares. It would suggest that the 1810 was either an exaggerated event or more likely an atypical event with a much higher reoccurrence period that the subsequent events. Sections of the alignment that may be vulnerable by such an event are the segments between km 20+500 to 21+600 and 22+850 to 23+400. Given that the 1810 event was an atypical event, design considerations for such and event would be counterintuitive and cost prohibitive as such an event would overwhelm most, if not all, of the drainage infrastructure in the area.



- Figure 6 – Topographic section and groundwater profile from Moneague in the south (left of figure) and continuing north to BH#8 on the right of the figure.



- Figure 7 - WRA's estimate of the total potential extent of the Moneague Groundwater Lake (1214 hectares). The alignment is indicated in yellow.

7.1.7.2 Seismicity

The OAS seismic risk maps of Jamaica (Figure 8, Appendix VII) shows that the project site lies in an area that can expect a Modified Mercalli Intensity of 7 with a 10% chance of exceedance in any 50 year period. Expected horizontal ground velocity is projected to be approximately 18 cm/sec and 245 – 270 gals for horizontal ground acceleration reducing toward the west. These predictions assume a significant earthquake event in the eastern parishes – the most geologically active part of the island. A more localised event may along the rejuvenated Mount Diablo Fault increase these values.

7.1.7.3 Landslide Susceptibility

Though no landslide hazard maps have been produced to the area traversed by the alignment the convergence of precursor factors that increase landslide risk in Jamaica are evident. These are steep slopes, fractured bedrock due to proximity to fault zones, competent rock overlying less competent rock (Tertiary Limestone over Cretaceous Volcanics) and the tendency for heavy, short and intense rainfall and the intended disturbance of existing slopes that are likely to have achieved equilibrium. The typical failure types in Jamaica are rock falls, rock slides, rock topples, debris flows and slides and lateral spreads[v]. In Jamaica landslides typically follow intense rainfall events as the events increase the pore-pressures in the surround soil and rock which leads to a decrease in the shear resistance of the soil/rock increasing the likelihood of failure. This increased risk of failure is positively correlated to the slope, degree of fracturing and depth of overburden and rainfall intensity and duration in Jamaica.

Prehistoric landslides have been documented west of Ewarton, St. Catherine in the Mount Diablo area. The slide is shown on the geological map (Figure 2) and is a complex failure of the White Limestone slipping over the Cretaceous basement rocks. Geographically, major slides in Jamaica are located principally in the Cretaceous basement rocks where they are exposed in the Inliers and coupled with steep slopes. Given the above their will be a significantly increased landslide risk along the alignment as it curves across the Mount Diablo Fault by Mango Grove and heads west passing Bailey Town until it reaches the limestone plateau of Mount Zion.

7.1.8 Air Quality

Particulate matter (PM) refers to discrete particles in ambient air that exist either as solid particles, or as liquid droplets. The sources of PM are: natural, e.g. pollen; a combination of natural and man-made in variable proportions, e.g. dust in a park, roadside dust, smoke from vegetation and wood burning; and wholly man-made, either: - naturally, e.g. household dust from skin shedding; or - activity-related, e.g. smoking, cooking and barbecuing, vehicle use, industrial activities, etc. The sizes of PMs cover a very wide range: from the tiniest in smokes and aerosols (e.g. perfumes), through the maximum respirable size 10 microns (µm) up to 'grit in the eye' sizes of 100 µm and upwards.

Many particles do not maintain a constant form during their lifetimes in the atmosphere: many agglomerate to become fewer, larger particles whilst others react chemically to become something different altogether. The normal fate of PM is deposition. The rate of deposition depends upon the size and density of the particle as well as atmospheric conditions. The deposition rate in still air approaches 90 to 100 per cent for particles that are larger than 0.5 µm, whilst particles smaller than 0.5 µm will tend increasingly to remain suspended in the air. Atmospheric turbulence is an important factor and can have opposite effects, ventilation and turbulence. On the one hand, ventilation disperses concentrations of PM, while on the other hand turbulence reduces the rate of deposition. Hence, the PMs' size distributions, their other physical and chemical properties and their concentrations in ambient air are highly variable, depending on the particular characteristics of the biosphere at issue (e.g. which geographic region, urban or rural) and the ecosystem involved (e.g. indoor, outdoor, roadside, street, etc.). The ambient air quality data generated for the present study are presented in Table 5.

Location			NEPA Guideline Microns (µm)	12 - 16/07/07	19 - 31/07/07	31/07– 10/07
1	X:246497 Y:166910	0+000				71.0
2	X:245882 Y:168108	1+300				34.0
3	X:242143, Y:173635, Z:612	14+600	150	107.0	22.0	95.0
4	X:240748, Y:175193 Z:507	16+500		92.0	55.0	38.0
5	X:239878 Y:176738 Z:487	18+450		89.0	63.0	36.0
6	X:236990 Y:180293	23+500				60.0

Table 5: Air Quality data from monitoring programme

Respirable particulates levels were well within the recommended ambient air quality PM10 guidelines established by NEPA

7.1.9 Noise

The noise level recorded for the site is recorded in Table 6 below.

The noise levels recorded for the locations monitored are currently within the guidelines set by NEPA.

Location			NEPA Guideline dBA	10/07/07	13/07/07	18 – 20/07/07	30/07/07	03/08/07	08/08/07	09/08/07
1	X:246497 Y:166910	0+000						48.7		
2	X:245882 Y:168108	1+300								
3	X:242143, Y:173635, Z:612	14+600	70	49.3	51.3	53.6				
4	X:240748, Y:175193 Z:507	16+500				60.1				
5	X:239878 Y:176738 Z:487	18+450		56.3		53.1	60.7			51.6
6	X:236990 Y:180293	23+500							57.6	

Table 6: Noise data from monitoring programme

7.1.10 Water Quality

No major groundwater or surface water pollution incidents were reported by Water Resources Authority within 1000 m of the site.

7.2 Biological Environment

The project site under investigation covers a distance of approximately 15 kilometers starting in the alluvia plain of Linstead then assending the limestone hills of Mount Diablo to Berkshire a distance of ten kilometres. The other section investigated runs for a distance of five kilometres, over primarily limestone deposits, from Faiths Pen to Moneague. The biological resources are very diverse as is also the case for land utilization. The area from chainage 0+000 to 10+000 is occupied by significant amount of settlements and population centres spanning the communities of Bynlos, Treadways, Bermady and Molluck.

The land use can be generally described as:

- Housing interspersed with subsistent farming.
- Grasslands interspersed with shrubs.
- Agricultural lands for large expanses of sugar cane and citrus.
- Tropical dry forest.

The area between chainage 18+500 to 24+000, which cover the communities of Faith Pen, Unity Valley, Pheonix Park and Moneague,.
The land use here can generally be described as:

- Tropical dry forest
- Pasture lands
- Housing

The vegetation associated with these areas are typical of that which is expected it be found in the interior areas of Jamaica. Based on the flora survey the vegetation type can be grouped into four sections, as follows

iv. Section A - 0+000 to 7+500 (housing intrespersed with subsistence farming and commercial farm lands).

v. Section B - 7+500 to 10+000 (primary limestone dry forrest).

vi. Section C - 18+500 to 21+600 (primary limestone forest interspersed with mined out grasslands and subsistence farming.

vii. Section D - 21+600 to 24+000 (pasture land along with housing and subsistence farming).

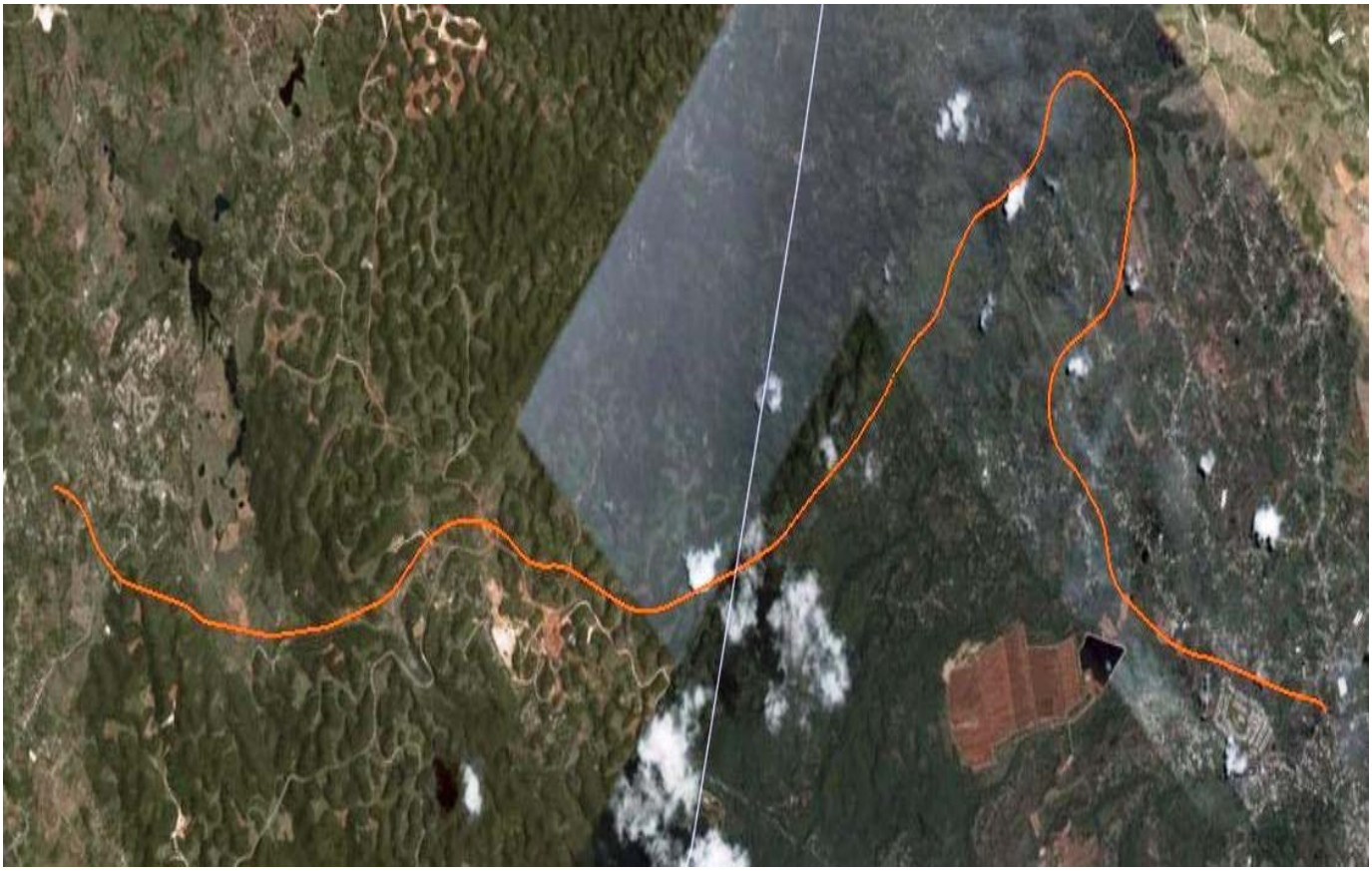


Plate 7.1: Aerial view showing an overall view of the vegetation along the complete route of the highway.

Plate 7.2: Arial view of chainage 0+000 to 3+000

Plate 7.3: Arial view of chainage 3+00 to 10+000

Plate 7.4: Aerial view of chainage 18+500 to 24+000 showing the vegetation cover

This segment of the project traverses over lands that are located between Berkshire and Mullock that have generally undergone significant disturbance in the vegetative coverage. The area is typical of Jamaica inland where there are alluvial areas intercropping with limestone. The varied topography of karst terrain, include intricate patterns of substrates and degrees of exposure, creates a wide variety of microhabitats and, consequently, a wide variety of species.

Section A: Alluvial Plain With Housing Subsistence Farming & Commercial Farms

This area covers the first 7.5 kilometres of the highway including the communities of Byndloss, Treadways, Berk Hall, Bermady and Bailey Town. The vegetation in this area is highly disturbed, with no signs of the original vegetation remaining, but has been replaced either by

housing, subsistence crops such as casava, and corn or commercial agriculture such as coconuts, citrus and sugar cane. Other introduced spieces, mainly fruit trees, such as ackee breadfruit, avacado banana and mango occurs frequently throughout this section.

Plate 7.5: Coconut and Orange farm in the Byndloss area at the start of the highway

Plate 7.6: Commercial citrus and sugar cane farm in the Recess Pen area at chainage 5+600

Plate 7.7: Subsistence farming - Casava and fruit trees ackee and mango in Treadways at chainage 3+ 800

Section B: Primary Limestone Dry Forest

The area is typical of Jamaica inland where there are alluvial areas intercropping with limestone. The varied topography of karst terrain, include intricate patterns of substrates and degrees of exposure, creates a wide variety of microhabitats and, consequently, a wide variety of species. This area can be classified as tropical woodland and are partly dominated by closed canopy dry limestone forest, significant portions of the forest is degraded and impacted by human activity (Plates 7.8) as indicated by clearings, the open canopy, and the presence of trumpet trees (*Cecropia peltata*). There is evidence that coal burning, felling for lumber and fence post have occurred in this area. The dominant speices in this area is Small Leaf Sweetwood - *Nectandre coreacia*

Plate 7.8: Example of the limestone Dry Forest as to be found in Section B (7+500 – 10+000)

Plate 7.9: Another view of the limestone Dry Forest as to be found in Section B (7+ 500 – 10+ 000)

Section C: **Primary Limestone Dry Forest**

Previous land clearing and exploitation for bauxite mining and agricultural use has resulted in the removal of the primary vegetation in some areas and re-colonization by grass, fern and shrubs. Pockets of primary forest remains and these are dominated by Sweet wood *(Nectandra Coreacea).* Reclaimed mined out lands in the Unity Valley area has been revegetated by grass and is being used as pastures, significant portions of the forest area have been disturbed for use of sussistence agriculture (see plate ….) and coal burning. Grass and vines. Are also a feature of this section.

Plate 7.10: Subsistence farming producing yam in the unity valley area at chainage 19+700

Section D: Pasture Lands With Housing & Subsistence Framing

This section is dominated by pasture lands much of which seems to have been abandoned and is interspersed with housing and subsistence farming. The abandoned pastures are dominated by African grass which was cultivated for cattle grazing with some scattered mature tress and shrubs, mainly Guango and Royal Palm. The open grassland nature of the habitat supports a limited number of birds such as seedeaters like Grassquits and Grasshoppers Sparrows. The ammodramus savannarum is an endemic species that is found in relative abundance in this section

Plate 7.11: Abandon pasture lands in the Phoenix Park area of Moneague at chainage 23+500

Plate 7.12: Abandon pasture lands in the Phoenix Park area of Moneague at chainage 23+500

7.2.1 Terrestrial Flora

Approximately ninety six plant species were identified (Table 7). These include a wide variation of native and introduced species, incorporating all the categories such as fruit trees, herbs, shrubs, flowering plants and vines. Many of the introduced species were from both commercial and subsistence agriculture which was most prevalent in section A these include; banana, orange, sugar cane, coconut, breadfruit, corn, cassava and ackee. Other introduced species were flowering plant and grass for improving aesthetics in the areas with housing developments mainly section A and Section D.

A complete listing of the entire flora population observed within the project is given in Table 7, of the total only two were endemic species (the Royal Palm and the Prickly Pole which both occurs frequently throughout the project area. Another significant feature of the plant species observed is the dominance of the orange (*Citrus Cenesis*) and the sugar cane (*Saccharum officinarum*) in section A, due to the passage of the project through extensive commercial farming of both species in that area.

Table 7: Flora identified along the Alignment

Common Name	Scientific Name	Growth Habit	Frequency	Section Identified
Logwood	*Haematoxylum campecianum*	Tree	O	A, B, D
Guinea grass	*Panicum maximum*	Grass	O	A, B, C, D
Coralita	*Antogonon leptopus*	Vine	O	A, D
Small Leaf Sweetwood	*Nectandre coreacia*	Tree	D	A, B, C, D,
African Tulip	*Spathodia campanulata*	Shrub	O	B, C
Prickly Yellow	*Zanthoxylum martinicence*	Tree	F	B, C
Marsh Fern	*Thelypteris pahustris*	Shrub	F	A, B, C, D
Glade Fern	*Deoaria acrostrichoides*	Shrub	O	C, D
Wild Popanax	*Acacia tortuosa*	Tree	F	A, D
Maiden Plum	*Comocladia pinnatifolia*	Tree	F	B, C
Guava	*Psidium guajava*	Tree	O	A, B,C, D
Mountain Cabbage	*Roystonia altissima*	Shrub	O	B, C, D
Red Birch	*Bursera simaruba*	Tree	F	B, C
Dogwood	*Piscidia piscipula*	Tree	O	B, C
Rose Apple	*Syzygium jambos*	Shrub	O	D
Pimento	*Pimenta Dioica*	Tree	O	A, C, D
Pundo Palm	*Butia capitata*	Tree	O	B, C
Wild Pine	*Bromeliad*	Tree	F	A, B, C, D,
Wild Tamarind	*Pithecellobium arboreum*	Tree	F	B, C
Lead Tree	*Leucaena luecocephala*	Tree	F	B, C
Coconut	Cocos nucifera	Tree	R	A, D

Bamboo	*Bambusa vulgaris*	Tree	O	A, C, D
Guango	*Samanea saman*	Tree	O	D, E
Mango	*Magnifera indica*	Tree	F	A, B, C, D
Sour Sop	*Annona muricata*	Tree	O	A, D
Trumpet Tree	*Ceropia peltata*	Tree	F	A, B, C, D
Pear Sweetwood	*Cinamomum montanum*	Tree	D	A, B, C, D
Blue Mahoe	*Hibiscus elatus*	Tree	R	C, D
Cedar	*Cedrela fissilis*	Tree	R	A, B, C, D
Pine	*Pinus caribaea*	Tree	F	A, C, E
Sugar Cane	*Saccharum officinarum*	Grass	F	A. D
Willow	*Casuarina equisetifolia*	Tree	F	C
Ackee	*Blighia sapida*	Tree	O	B, D
Devil Horse Whip	*Achyranthes indica*	Shrub	O	B, C
Orange	*Citrus cenesis*	Tree	F	A, C, D
Bougainvillea	*Bougainvillea peruviana*	Shrub	O	A, D
Custard Apple	*A. reticulata*	Tree	R	A
Royal Palm	*Roystonia princeps*	Tree	O	A, C, D
Spanish Needle	*Bidens pilosa*	Shrub	F	A, C, D
Avacado	*Persea americana*	Tree	F	A, C, D
Banana	*Musa sapientum*	Shrub	F	A, C, D
Periwinkle	*Catharanthus roseus*	Shrub	O	A, D
Croton	*Codianeum variegatum*	Shrub	O	A, D
Oleander	*Nerium oleander*	Shrub	O	A, D
Bermuda Grass	*Cynodon dactylon*	Grass	O	A, D
Christmas Bush	*Eupatorium odoratum*	Shrub	O	A
Cockspur	*Pisonia aculeata*	Tree	F	A, C, D
White Sage	*Lantana camara*	Shrub	F	A,C, D
Wild Tobacco	*Pluchea carilinesis*	Shrub	O	C, D
Hog Plum	*Spondias mombin*	Tree	O	A
Vervine	*Stachytarpheta jamaicesis*	Shrub	O	D
Ballard Bush	*Urena lobata*	Shrub	F	A, B, C, D
Oil Nut	*Ricinus communis*	Shrub	O	A, D
Cerasse	*Momordica balsamina*	Vine	O	A
Nightshade	*Urechites lutea*	Shrub	F	A, C
Breadfruit	*Artocarpus altilis*	Tree	F	A, D
June Plum	*Spodias dulcis*	Tree	O	A
Pineapple	*Ananas comosus*	Herb	O	A
Shame Old Lady	*Mimosa pudica*	Weed	O	A, D
Calabash	*Cresentia cujete*	Tree	R	D
Corn/Maize	*Zea mays*	Shrub	O	A, C
Almond	*Terminalia catappa*	Tree	F	A, C, D
Natal Grass	*Rhynchelytrum repens*	Grass	O	A
Ficus	*Ficus aurea*	Tree	F	A, D
Prickly Pole	*Bactris jamaicana*	Tree	F	A, B, C, D
Goatweed	*Capraria biflora*	Shrub	O	A, C

Wild Caia	*Cleome viscose*	Grass	O	A, D
Dandelion	*Cassia occidetalis*	Shrub	F	A, C, D
Rattleweed	*Crotalaria retusa*	Weed	F	D
Broomweed	*Sida acuta*	Weed	F	A, B, C, D
Poinciana	*Delonix regia*	Tree	F	A, C, D
Susumber/Gully Bean	*Solanum torvan*	Shrub	F	A, D
Bastard Cedar	*Guazuma ulmifolia*	Tree	F	B, C
Scorpion Weed	*H. indicum*	Weed	O	D
Noni	*Morinda citrifolia*	Tree	O	B
Guinep	*Melicoccus bijugatus*	Tree	O	A, B
Pussley	*Portulaca oleracea*	Weed	O	A
Sweet Cup	*Passiflora* maliformis	Vine	O	A
Quickstick	*Gliricidia sepium*	Tree	F	A, C, D
Starapple	*Chrysophyllum cainito*	Tree	R	A, D
Red Bean Vine	*Abrus precatarius*	Vine	R	B
Yam		Tuber	R	

R – Rearly; O – Occasional; F – Frequent; D - Dominant

7.2.2 Terrestrial Fauna

A total of 36 species of birds were observed during the survey, of which 9 are endemic to Jamaica (Table 8). Several species of birds inhabit the secondary dry limestone woodland at Section B and C. Jamaican woodpeckers, doves, parakeets, hummingbirds, orioles and vireos are common all year round in the scrubby undergrowth of this type of habitat (Downer and Sutton, 1990). Notable was the observation of a flock of Yellow-billed Parrots flying over the limestone woodland at Section B and C. The dominant species observed in Section A and D were the Grassquit and the Loggerhead, no nocturnal birds were observed, although the owl and bat would be expected to inhabit this area.

Table 8: Fauna Identified along the alignment

Residents			
Common names	**Scientific names**	**Section Observed**	**Frequency**
White-winged dove	*Zenaida asiatica*	C	
Vervain Hummingbird	*Mellisuga minima*	A	
Stolid Flycatcher	*Myiarchus stolidus*	C, D	
Turkey Vulture	*Carthartes aura*	B, C	
Nothern Mockingbird	*Mimus polyglottos*	C	
Ground Dove	*Columbina passerina*	D	
Jamaican Elaenia	*Myiopagis cotta*	B, C	
White-crowned Pigeon	*Columba leucocephala*	A	
Loggerhead Kingbird	*Tyrannus caudifasciatus*	B, C	
Rofous trouted solitaire	*Myadeste genibarbis*	C	
Bananaquit	*Coereba Flaveola*	A,C	
Jamaican Oriole	*Icterus eucopteryx*	D	
Smooth-billed Ani	*Crotophaga*	A	
Olive-throated Parakeet	*Aratinga nana*	C	
Royal Tern	*Sterna Maxima*	D	
White-winged Dove	*Zenaida asiatica*	D	
Greater Antillean Grackle	*Quiscalus niger*	A, C, D	F

Greater Antillean bull finch	*Loxigilla Violacea*	B, C	
Black faced Grassquit	*Tiaris bicolor*	D	
Yellow faced Grassquit	*Tiaris olivacea*	C, D	
Tricoloured Heron	*Egretta tricolor*	A	
Cattle Egret	*Bubulcus ibis*	C, D	
Endemics			
Jamaican woodpecker	*Melanerpes radiolatus*	A, C	
Rofous tailed flycatcher	*Myiarchus validus*	B,C	
Jamaican Becard	*Pachyramphus miger*	A	
White-winged Thrush	*Turdus aurantius*	B	
Yellow-billed parrot	*Amazona collaria*	B, C	
Orange quit	*Euneornis campestris*	A, D	
John Crow	*Corvus jamaicensis*	B	
Jamaican Vireo	*Vireo modesto*	C	
Yellow–shouldered grassquit	*Loxipasser anoxanthus*	D	

R – Rearly; O – Occasional; F – Frequent; D - Dominant

Butterflies

Several species of butterfly were observed feeding on flowering shrubs at Stations Section A, B, C and D Butterflies are important pollinators and those seen at the site are listed in Table 9. The Citrus Swallowtail was observed in Section D. All species observed were common and are typically found in the area of Jamaica with vegetation as earlier described in the project area. A list of the butterflies observed on the project site is given in Table 9 and the photograph of a few is presented in Plates 7.13 & 7.14.

N-Native

E-Endemic

Common Name	Species	Habitat
Little Suphur	*Eurema lisa euterpe*	N
Zebra	*Heliconius charitonus*	N
Dryas	*Dryas iulia*	N
Mestra	*Mestra dorcas*	E
Southern White	*Ascia monuste eubotea*	N
Malachite	*Siproeta stelens*	N
White Peacock	*Anartia jatrophe jamaicensis*	E
Monarch	*Danaus gilippus*	E
Lignum Vitae butterfly	*Kricogonia lyside*	N
Cabbage white	*Ascia monuste*	N
Flambeau	*Dryas iulia delila*	N
Citrus swallow tail	*Papilio andraemon*	E
Jamaican satyrid	*Calisto zangis*	E

Table 9: List of butterflies along the alignment

Plate 7.13: Butterfly observed in Section C

Plate 7.14: Butterfly observed in Section C

Other Fauna

A number of other species such as grasshopper, termites and snails were seen which was in relatively low density as to what would be expected of similar secondary forest and grasslands. The dragonfly was observed in relative abundance mainly in Sections C and D. No rats on mangoose were observed although they are typically expected to be found in this area. Cows goats and donkey were observed grazing in some of the pasture lands. Dogs were observed in Sections A and D, the areas with housing developments.

Plate 7.15: Snail observed in Section C

Plate 7.16: Lizard observed in Section C

Plate 7.17: Termite Nest observed in Section C

7.3 Socio-economic Environment

7.3.1 Land Use

Currently the lands are used for subsistence farming of crops such as corn and yam in the Moneague area and some sugarcane in the Linstead area. In addition there is some diary farming in the Moneague area mainly by the Bauxite Company WINDALCO.

Survey findings revealed the following:

- 43% of the land is used for subsistence farming of tubers – e.g. yam, cassava. Some grow corn.
- 36% - cultivate vegetables
- 19% - cultivate fruits e.g. orange
- 3.5% - A few engage in livestock farming (3.5%) – rearing of goats, cows and chickens.
- 82% - of persons polled believed that there was idle land in the area.
- Of the 82% (above), 50% felt that there was too much under-utilized and idle land. The idle land may facilitate relocation of persons affected by the road.

7.3.2 Developmental Activities:

A community centre is currently being constructed in the Phoenix Park Community.
There are no other planned developmental activities apart from the highway project within the next 3 years.

7.3.3 Demography, Employment and Social Infrastructure

The average age of the population lies between 26 and 65 years, with a predominantly male headed household. The average household has 4 – 8 persons per household. Unemployment in many of the communities is high and the construction of the highway can increase the availability of jobs for communities impacted by it both directly and directly. It will also provide direct employment for skilled and unskilled labourers – e.g. masons, flagmen. Direct employment – vendors and cook shops.

Employment - Direct employment – vendors and cook shops. With 25% of the respondents falling in the category of labourers, the developers of the highway will find persons to work on the highway. This is supported by survey findings:

- Employment status: 53% is self employed; 25% employed; 22% unemployed
- The major areas of employment are - farming (16%); small business operators who employ 1 – 10 persons (24%); housewives (8.5%); domestic helpers/informal trader/labourers/stall operators (25%); nurse/teacher/security/fireman/clerk (7%). A few are employed as welders and drivers.
- 86% of the persons interviewed believe that the project it will create employment.

Access and Reduce Travel Time - It will also facilitate easier access to other communities and towns. The residents of Moneague and surrounding communities currently go to Ocho Rios for recreational activities. Many attend churches and corner bars/ lounges within the community. According to some residents of St. Ann (Schwallenburg) they at times utilize the community centre developed by the bauxite company – WINDALCO. As such many are looking forward to the construction of the highway, which will reduce traveling time to Ocho Rios and the challenges of coping with slow moving, heavily laden vehicles traveling the Mount Rosser route. This is supported by survey findings:

- 92% of the persons interviewed saw the project as needed and as reducing traveling time to school, work, church, places of recreation, hospital and fire-stations.
- 82% - easier access and reduce travel time to church and places of entertainment
- 85% - easier access and reduce travel time to hospital, fire and police
- 87% - easier access and reduce travel time work and school
- 82% - easier access and reduce travel time to church and places of entertainment. 99% of the persons polled belonged to a church.

7.3.4 Public Perception of Project

- 66% of the residents believe that the highway will attract more business to their communities.
- 52% believes that it will destroy the natural environment
- 64% believe that it will not contribute to flooding
- 84% believes that it will cause noise and dust nuisance during construction.
- Some persons believe that it will contribute to place being a 'ghost town' as vehicles are diverted to highway. The Faiths Pen Vendors see the bypass as having negative impact on their business and would like to see incorporated in it a rest stop or access and exit points off the highway.
- 86% believes it will provide jobs (directly and indirectly).
- 38% believes that it will be disruptive, especially during the construction phase. This was more evident among the Faiths Pen Food vendors who saw it as reducing the level of business activity they now experience. Their fear is that motorists will bypass their stall when they use the Mt. Rosser By-pass. They welcome it but want it planned with them in mind – e.g. Rest Stop or direct exit and re-entry of the highway for persons who wish to visit Faiths Pen.
- 60% feels that the project will affect the community
- 86% - Better transportation
- 52% - project will destroy natural environment; 48% - No
- 57% - believe it will damage farm land

7.3.5 Implications of the project during Construction:

Many residents do not perceive that construction will hinder commuter travel. 38% of the persons polled believe that it will be very disruptive, especially in terms of dust and noise nuisance.

57% - will cause damage to farmland

36% - contribute to flooding

84% - project will cause dust nuisance

7.3.6 Project Awareness:

- 96% of the persons interviewed were aware of the project
- 92% feels that the project is needed. (64% believe that it is greatly needed).

7.3.7 Health and Safety

There is a police station in Moneague and a clinic. The nearest major hospital is in St. Anns Bay. There is also a fire station in St. Anns Bay. St. Anns Bay is a major town in the parish of St. Ann.

The communities polled seemed organized. Each community either had a church or was in close proximity to one. Others had citizens association, farmers group and youth groups. The communities also had access to hospitals and clinics, police stations and fire departments. The social linkages have the ability to positively impact the social health of residents within these communities. The highway will increase access to hospitals, clinics, the police and the fire departments. One resident remarked that it will reduce the number of persons who die in transit because of lengthy delays getting to hospitals.

- 55% of the persons interviewed believe that the project will afford easier access to fire and police.
- 85% believed it would afford easier access to hospitals and clinics

Noted Amenities:

- **St. Catherine** –
    - Linstead: has an active Disaster Preparedness Committee
    - Health Centre
    - Police Station
    - Fire Station

- **St. Ann**
    - Moneague Health Centre
    - St. Anns Bay Hospital
    - Moneague Police Station
    - Fire Station

7.3.8 Sewage

Most of the households use pit latrines (96%) and soak away pits (99%). In many instances both pit latrines and soak away pits are used in conjunction. This may result from inadequate domestic water supply.

7.3.9 Garbage Disposal

Garbage disposal – the primary means of garbage disposal is burning followed by stock-piling. In some of the more developed communities, such as Faiths Pen (Food Vendors) garbage is collected by trucks.

- Survey findings revealed that 98% of respondents burn their garbage and 92% burried it.
- 2 farmers uses a biodigester to treat waste

7.3.10 Archaeological and Cultural Heritage

Historical Importance:

Only 21% of the sample population was aware of any place of historical significance or that should be protected. Of this 21%, 34% felt that the places had potential to be developed as tourist attractions. Three places were identified by citizens. They are the orchid sanctuary, the Jacobie Caves and the Phoenix Park Great House in St. Ann.

According to the residents you can enter the **Jacobie Cave** from one entrance and exit at another. The middle is very dark and has water flowing through it. The **Orchid Sanctuary** still has orchids and use to be visited by nature lovers. Both the cave and the sanctuary are in the Schwallenburg area of St. Ann.

Phoenix Park Great House - There is also a **great house in Phoenix Park** (St. Ann) – which the residents see as potential for tourist attraction

These places once used to be visited by school children and tourists. Over the years they have not been adequately maintained and the visitation reduced. They still have the potential to be used as tourist attractions especially for nature lovers.

8.0 POTENTIAL IMPACT AND MITIGATION MEASURES

An impact is any change to the existing condition of the environment caused by human activity or an external influence. Impacts therefore may be positive (beneficial) or negative (adverse). They may also be direct or indirect, long-term or short-term, and extensive or local in effect. Impacts are termed cumulative when they add incrementally to existing impacts. Both positive and adverse environmental impacts could arise during the site preparation, construction and the operations phases of the Mount Rosser Bypass Highway.

8.1 Loss of terrestrial habitat and biodiversity

Impact

The clearing and removal of trees and vegetation during the highway construction will result in the loss of a significant part of the existing dry limestone forest and, as a consequence, a reduction in the habitat for the flora and fauna. Noise, vibrations, and intrusive activities related to construction works also will tend to scare away the fauna remaining in close proximity to the site after vegetation clearance.

Mitigation

The overall objective of this mitigation is to minimize and where possible restore disturbed areas

- Site clearance must be preceded by identification and relocation of all endemic plants and ecologically valuable specimens that can be later used for re-vegetation of exposed areas. Bird feeding trees should also be planted as part of the re-vegetation process
- Establish a plant nursery to preserve the plants for relocation until ready for replanting. These plants are to be placed and maintained in a plant nursery on site until ready for transplanting. These activities should be guided by an appropriate and approved management plan.
- Site clearance should seek to avoid removal of the large trees.

- A plan must be put in place for the rescue, relocation and treatment of fauna injured in the clearing process

8.2 Loss of land use options

Impact

Construction of the highway will involve the large scale removal of vegetation and the erection of permanent road surface on what is essentially a green field site. This will result in a loss of the options for alternative use of the land and thus represents an irreversible commitment of land resources. Loss of the option to utilize this stretch of land for any other purpose can be considered to be a negative impact.

Mitigation

Mitigation is not considered for this impact but is addressed in section 9 under the heading Consideration of Alternative.

8.3 Soil erosion

Impact

Vegetation clearance and excavation works for construction of the highway will expose soils in the affected areas leaving them vulnerable to erosion by surface run-off during heavy rainfall. The hilly topography of the area exacerbates this potential of this negative impact.

Mitigation:

- As much as possible, minimize the area of exposed soil at any given time.
- Re-vegetate exposed soils with appropriate species as soon as possible.
- During construction direct flows from heavy runoff away from areas that are threaten by erosion.

8.4 Noise

Impact

The use of heavy equipment during site clearance and construction works will inevitably generate noise, which may create a nuisance for nearby residents and workers. This is a negative impact but is not considered to be significant, as the duration will be short-term.

Mitigation:

- Local residents within a distance of impact should be given notice of intended noisy activities so as to allow then to make any necessary preparation.
- Workers operating equipment that generates noise should be equipped with the appropriate noise protection gear.
- Construction activities that will generate disturbing sounds should be restricted to normal working hours.

8.5 Dust

Impact

The site clearing and excavation activities will produce fugitive dust which may result in increased levels of air borne particulate matter. This situation will be worst during the dry season and during times of prevailing wind. Most of the highway alignment is outside of population centre, and this impact will be of greater significance in areas close to human settlement. The occurrence of dusting is periodic and short-term, lasting for the duration of the construction activity.

Mitigation:

- Exposed surfaces should be regularly wetted in a manner that effectively keeps down the dust.
- Stockpiles of fine materials (e.g. marl) should be wetted or covered with tarpaulin during windy conditions.
- Workers on the site should be issued with dust masks during dry and windy conditions.

9.0 CONSIDERATION OF ALTERNATIVES

9.1 Alternative Site

The alternatives considered are presented in relation with the five identified sections of the existing road, as described below.

-	section 1:	alternative 1.0	-	11.52 km
-	section 2:	Linstead Bypass	-	7.04 km
-	section 3:	alternative 3.0	-	21.86 km
-	section 4:	existing road	-	7.37 km
-	section 5:	alternative 5.0	-	17.64 km

Total length of Project: - 65.43 km

For each section, the various alternatives have been indexed according to three different levels of improvement:

S-0 – is corresponding to the existing road without improvements, but with normal maintenance;
S-1 – is corresponding to local improvements to the existing road;
S-2 – plus a), b), c), is corresponding to new alignment alternatives; with S corresponding to the Section number.

9.1.1 Section no. 3, Linstead to Moneague

For this section, Linstead to Moneague five alternatives were considered.

i). Alternative 3.0: The existing road through Ewarton and Mount Diablo, with normal maintenance, considered as the reference solution for economic comparison purpose. The actual length is 21.86 km.

ii). Alternative 3.1: The existing road through Ewarton and Mount Diablo, with local improvements as follows:

- between KPO and KP 7.16 (Ewarton): strengthening of the pavement including 150 mm binder base course + overlay 50 mm AC + DBST on the shoulders
- between KP 7.16 (Ewarton) and KP 15.17 (Faiths Pen): local improvements of the geometrical characteristics in order to raise the 50 km/h standard, including the construction of an additional climbin g lane on a total length of 7,300 m, and an estimated length of retaining walls of about 3,200 m
- between KP 15.86 (Faiths Pen) and KP 21.86 (Moneague): local improvements of the geometrical characteristics in order to raise the 60 to 80 Km/h standard, including the construction of an additional climbing lane on a total length of 3,050 m

The estimated total length after geometrical improvements is 20.94 km.

iii). Alternative 3.2a: The proposed route corrider, derived from the design prepared by Lamarre Valois International in 1974 with local changes, is composed partially of a new alignment, and partially of local improvements of the existing road. The breakdown is as follows:

- starting at the end of Linstead Bypass, the alternative corridor is following the general direction of the Bypass to the north. The route is running up to KP 4.7 in a flat to hilly terrain, west of the existing secondary road to Russel Pen and Bermaddy, in order to limit the impact of the future road on the already built-up areas. On that section, the reference design speed could be 80 Km/h.
- the proposed alignment is then oriented to the west, overtaking by the north the existing bauxite mud ponds of Alcan. The terrain is becoming mountainous, with a very steep longitudinal slope to raise

the existing road around Mount Rosser, downstream the Alcan industrial waste dam. The proposed road is crossing (under) the existing ropeway used by Alcan to carry the bauxite materials to their works.

The estimated length is 5.54 km, with a design speed limited to 50 to 60 Km/h, the estimated length of climbing lane 4,480 m, and a provision has been made for the construction of 564 m of retaining wall.

- from that point, the alternative 3.2a is similar to the alternative 3.1 up to Moneague

The estimated total length including the new alignment and the geometrical improvements of the existing road is 19.71 km.

iv). Alternative 3.2b: The proposed route corridor is composed partially of a new alignment, and partially of local improvements of the existing road. The breakdown is as follows:

- starting at the end of Linstead Bypass, the 3.2b alternative corridor is similar to the 3.2a alternative up to around KP 3.5. From that point, the alternative is oriented to the north, to overtake Bermaddy by the west and get to the bottom of the mountain range. On that section, estimated to be 5.1 km long, the reference design speed could be 80 Km/h.
- the alternative is then turning west in a very mountainous terrain to join the village of Mullock, from where the alignment follows the corridor of an old parochial road the top of the range. On that section of 5.0 km long, the reference speed will be 50 – 60 Km/h, with an additional climbing lane all along. For that particular section, a provision for 100 m of bridge construction, and 1,800 of retaining walls has been made.

- From that point, the proposed alignment is partially reusing a road platform constructed by Alcan for bauxite mining works purpose, before joining the existing road at Faiths Pen (KP 15.17).The estimated length of this section is 4.02 km, along which the design speed could be 60 – 80 Km/h, assuming that around 50 % of earthworks are reusable, and
- From that point, the alternative 3.2b is similar to the alternatives 3.1 and 3.2a up to Moneague.

The estimated total length including the new alignment and the geometrical improvements of the existing road is 19.96.

v). Alternative 3.2c: This route corridor has for objective to bypass the town of Ewarton, which creates a bottleneck to the transit traffic.

- the proposed alignment first reuses the existing road between Linstead and Ewarton up to KP 5.52 (point located west of Alcan Works entrance).
- From that point, the alignment is oriented north to join the alignment selected for alternative 3.2a. Along that section, the topography is mountainous, a climbing lane will be needed for the whole length. The proposed alignment is crossing twice Alcan roadway.
- After joining alternative 3.2a, the alternative 3.2c is similar to the alternatives 3.1 and 3.2a up to Moneague.

The estimated total length including the new alignment and the geometrical improvements of the existing road is 21.60 km. The total length could be less (around 20.0 km) if the alignment reuses a private Alcan road. But at this stage of the study and without further information, the more favourable option has been considered.

9.2 No Action Alternative

- Long delays on Mount Rosser in case of accidents or any blockage of roads by heavy vehicles
- Very long delays can be experienced between Ewarton and Moneague in the case of accidents or any blockage of the road, and
- On the same section, the crossing of Mount Diablo is very difficult for loaded trucks.

10.0 OUTLINE MONITORING PROGRAMME

If a permit is granted for the proposed development, and before site preparation and construction activities begin, a Monitoring Programme should be prepared for submission to NEPA, for their approval. The aim of the Monitoring Plan is to ensure the following:

- compliance with relevant legislation
- implementation of the mitigation measures provided
- conformance with any General or Specific Conditions as outlined in the permit
- long-term minimization of negative environmental impacts.

The Monitoring Plan should include the following components:

• Inspection protocol
• Parameters to be monitored, which should include
  - Ambient air quality
  - Noise
• Construction monitoring
  Worker health and safety
  Disposal of solid waste
  Handling and disposal of hazardous material
  Disposal of liquid waste
  Burning of vegetative matter
• Materials handling and storage
• Covering of haulage vehicles
• Transportation of construction materials
• Deployment of flaggers and signposting
• Storage of fines and earth materials

The duration of the monitoring programme should be for the entire construction period,

with monthly reporting. The Monitoring Programme cannot be prepared in detail before the permit is received from NEPA as Terms and Conditions of the permit must be taken into consideration, and included in the monitoring programme as appropriate.

LIST OF REFERENCES

i. Global Warming Means Drier Summers for Caribbean, Central America, Environment News Service, April 17, 2006

ii. Mount Rosser Rehabilitation Project, RPS (UK), Nov 2006

iii. Jamaica Underground: Caves, Sinkholes and Underground Rivers, 1st edition 1963 (revised 1997), The Press - University of West Industry, ISBN 976-640-055-5

iv Highway 2000 Project, Hydrology Report Volume I, Dessau-Soprin, June 2000

v. Landslides in Jamaica: Extent, Significance and Geological Zonation, by Rafi Ahmad, published in Environment and Development in the Caribbean: Geographical Perspective, edited by David Barker & Duncan FM McGregor, 1995, UWI Press

Adams, C.D., 1972. *Flowering Plants of Jamaica*. University of the West Indies.

Bond, J., 1985. *Birds of the West Indies*. Collins**.**

Brown, F.M. and Heineman, B., 1972. *Jamaica and Its Butterflies*. E.W. Classey Ltd

Downer A. and R. Sutton., 1990. *Birds of Jamaica – A Photographic Field Guide*. Cambridge University Press.

Stiling, P., 1999. *Butterflies of the Caribbean and Florida.* MacMillian Education Ltd.

Bibby C.J.; Jones, M.J. and S.J. Marsden. 1998. Expedition Field Techniques: Bird Surveys. Expedition Advisory Centre, Royal Geographical Society, London.

C. Dennis Adams. The Blue Mahoe and Other Bush - An introduction to plant life in Jamaica. University of the West Indies, 1972.

Ingeroute Study, 1996. *A1 Upgrading –Feasibility Study*; Vol. 1 Comparison of Alternative; Ministry of Transport, Jamaica