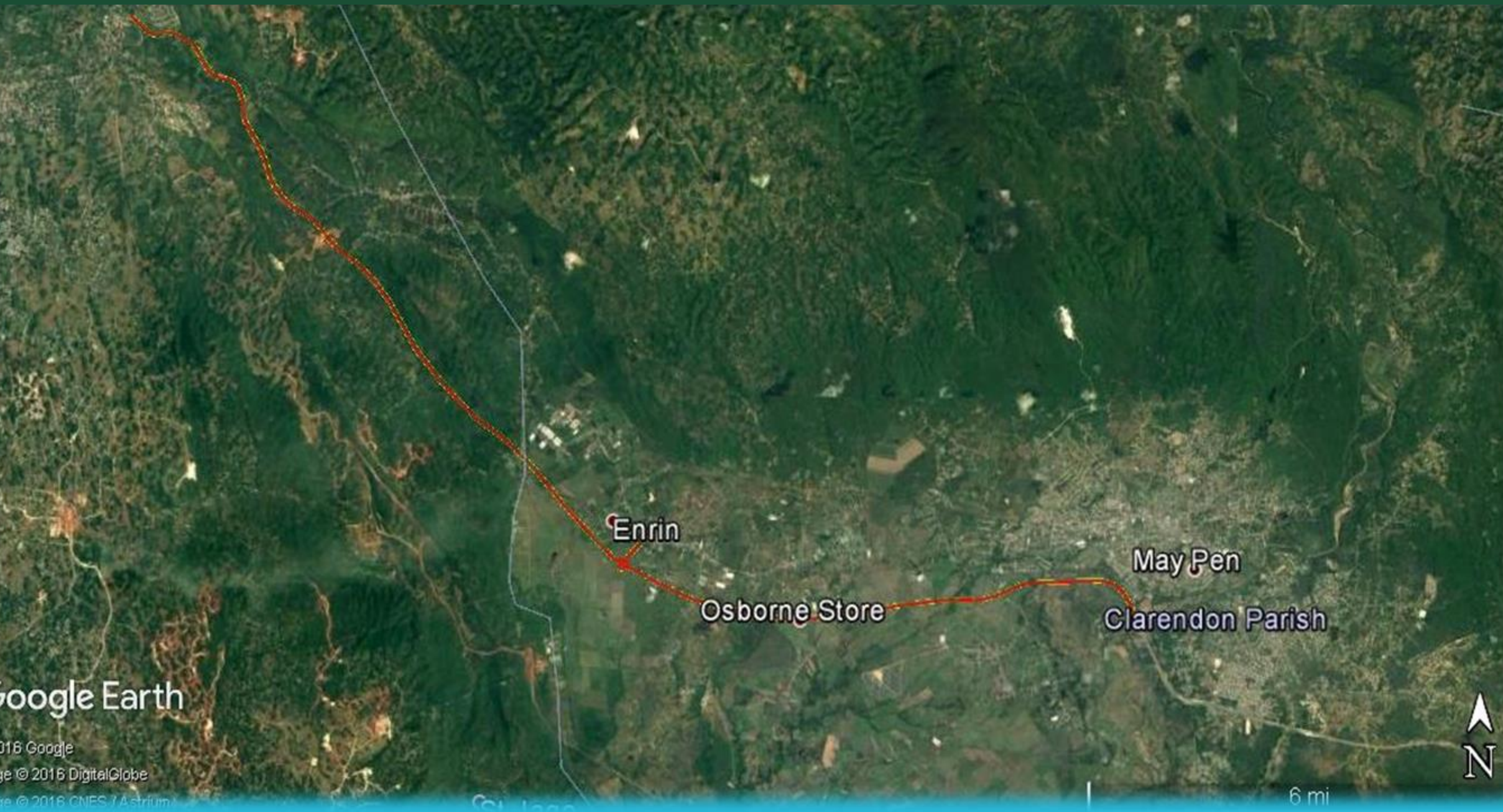
Addendum to 2007 Environmental Impact Assessment

Highway 2000

Phase 1C May Pen to Williamsfield



Prepared For

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Completion of this report would not have been possible without the inputs of the ESL project team which included:

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LIST OF ACRONYMS

asl	above sea level
BOD	Biochemical Oxygen Demand
dBA	decibels
EDs	Enumeration Districts
EIA	Environmental Impact Assessment
ESL	Environmental Solutions Ltd.
FHA	Federal Highway Administration
GOJ	Government of Jamaica
GPS	Global Positioning System
JNHT	Jamaica National Heritage Trust
JPSCo.	Jamaica Public Service Co
LEDPA	Least Environmentally Damaging Practicable Alternative
MGD	Mines and Geology Division
NHT	National Housing Trust
NEPA	National Environment and Planning Agency
NRCA	Natural Resources Conservation Authority
NROCC	National Road Operating & Constructing Company
NWC	National Water Commission
OSHA	Occupational Safety and Health Administration
PASMP	Protected Areas System Master Plan
PIOJ	Planning Institute of Jamaica
PPM	Parts per million
PM	Particulate matter
PVC	Polyvinyl Chloride
SEA	Strategic Environmental Assessment
SDC	Social Development Commission
STATIN	Statistical Institute of Jamaica
TPDCo	Tourism Product Development Company
TSS	Total Suspended Solids
TWA	Time Weighted Average
UNDP	United Nations Development Programme
UWI	University of the West Indies
WRA	Water Resources Authority

EXECUTIVE SUMMARY

This document represents the Draft Final Addendum to the 2007 Environmental Impact Assessment for the realignment of Highway 2000 Phase 1C: May Pen to Williamsfield. This Addendum was commissioned by the National Road Operating & Constructing Company (NROCC).

NROCC has proposed to construct Phase 1C of the May Pen to WIlliamsfield segment of Highway 2000. This alignment is a part of the Highway 2000 Sandy Bay to Williamsfield that received an Environmental Permit in 2007 following the conduct of an Environmental Impact Assessment (EIA) and submission of the requisite Permit Application Forms. The previous EIA highlighted several potential impacts that militated against the feasibility of the proposed route. As such, NROCC has subsequently reviewed the alignment.

The alignment of Phase 1C begins at chainage K43+500 and crosses the Rio Minho bridge just before K44+000. The alignment continues westerly and the realigned section of this phase starts at K48+000 which is 5km west of the start point (43+500). The road continues in a westerly direction and traverses south and parallel to the existing A2 main road (Bustamante Highway) and south of the major settlements at Four Paths, Osborne Store, Toll Gate, and Clarendon Park. The highway continues westerly and through the community of St. Toolis. The design speed for this segment of the highway will be 110 km/h.

At the entry point of St. Toolis (between K58+500 and K59+000), the alignment continues through hilly terrain and will have a design speed limit of 80 km/hr. A vertical gradient of 6% is required between St. Toolis and Williamsfield to achieve a change in ground level of almost 100 meters.

The realigned segment ends at K67+500 and joins the existing Melrose Bypass, which will be incorporated into the new alignment that entails upgrading to a four-lane dual carriageway with a speed limit of 80 km/hr. The road crosses the railway line at K71+000, before terminating just east of the Corrugated Metal Pipe bridge (CMP) or "pipe arch" in the vicinity of the roundabout at Williamsfield (K71+770). The entire Phase 1C alignment is 19.5km in length.

The EIA is intended to meet the Government of Jamaica's (GOJ) legislative and regulatory requirements for development permitting, and in that regard the salient pieces of legislation for the Phase 1C Highway realignment include the following:

1. The Natural Resource Conservation Authority (NRCA) Act (1991) and The Natural Resources Conservation (Permits and Licences) (Amendment) Regulations, 2015 require an application for and receipt of an Environmental Permit from the National Environment and Planning Agency (NEPA) for construction and operation of a new highway;
2. The Water Resources Act of 1995 requires the Water Resources Authority (WRA) to comment on the Terms of Reference (TORs), the project in general and the EIA Report regarding the

prevention of contamination to both surface and ground water resources. The data gathering process for this EIA Report has included a data request to the WRA in respect of surface and groundwater; hydrostratigraphy maps, locations of wells and lakes and other relevant parameters.

3. The Quarries Control (Amendment) Act, 2015 requires that any quarries used to provide material for the project should be licensed.
4. The Toll Roads Act, 2002 provides for the designation of specified roads as toll roads.

A multi-disciplinary team of experienced scientists and environmental professionals was assembled to conduct the required resource assessment, generate and analyse baseline data, and determine potential impacts and recommendations for mitigation measures. An iterative approach among the environmental team members and other project professionals was adopted, and was facilitated by fortnightly team meetings as required. The team utilized the Charrette-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.

Physical, biological and socioeconomic assessments were conducted. The findings of these assessments are presented below under the headings *The Existing Environment* and *Impacts and Mitigation*:

THE EXISTING ENVIRONMENT

Physical Environment

<u>Geomorphology/Topography</u>

The geomorphology of the project area can be broadly divided into two sections: the alluvial plain on the eastern half and the limestone karst terrain on the western half of the proposed highway.

The alluvial plain is relatively flat extending from the eastern boundary of the highway alignment in May Pen (K43+500) to Clarendon Park (K59+000) in the parish of Clarendon. Elevation ranges from 39 m (130ft) in the community of Decoy to 69 m (230 ft.) in May Pen.

The western half of the highway passes through an upland area consisting of limestone karst topography extending from Clarendon Park (K59+500) to Williamsfield (K71+770) at the end of the alignment. The type of karst landform is referred to as doline karst. Dolines are depressions or sinkholes normally circular or semi-circular in plan with diameter varying from a few metres to over 1km (Sweeting 1958). The dolines are interspersed with conical, semi-conical and elongated hills.

<u>Geology</u>

The May Pen to Williamsfield highway alignment passes through two main geological formations; Surficial deposits consisting of alluvium, and the Miocene, Newport Limestone of the White Limestone Group.

The major structural features are the geological faults which cross the highway alignment at three different locations, and the Porus/Williamsfield Graben structure in the Melrose Hill area of Manchester. There are many NW-SE and NNW-SSE trending faults in the St. Toolis to Williamsfield area (hilly terrain of project site), that have an impact in the area. The alignment which passes through the highland of St. Toolis and Reeves Wood are closely aligned in the direction of the faults and this reduces the number of faults which cross the alignment.

Soils

The Soil Classification Map developed by the Rural Physical Planning Unit of the Ministry of Agriculture shows that the soil type varies over 3 distinct areas: May Pen to Four Paths; Four Paths to Clarendon Park and Clarendon Park to Williamsfield.

In the May Pen to Four paths area, the soil is classified as the Agualta Vale clay loam which generally has poor internal drainage. Continuing further west to Clarendon Park, the highway alignment passes through the Rhymesbury clay and Four Paths Clay and the St. Ann Clay Loam. The soil type exhibits low to moderate erodibiliy and poor internal drainage.

The area between Clarendon Park and Williamsfield consists predominantly of the Bonny Gate Stony Loam. The Bonny Gate soil type is characterized by its sandy loam texture with high erodibility, very low moisture content and very rapid internal drainage.

With respect to engineering soil, the dominant soil in the alluvial section of the alignment is yellowish brown clay. Field work conducted in the Flemmings Gully in the Toll Gate area (200m north of K5+300) show evidence of firm to stiff yellowish brown clay exposed on the side of a 4m high gully bank. Within the karst limestone, reddish brown clay soil is found as the weathered product of the limestone, particularly in the Redberry and Porus areas in Manchester where the karst features are more subdued (Figure 4.43)

Natural Hazards

Landslide Hazard and Slope Stability

Landslide susceptibility for the project site is not available, however, a Landslide Hazard Zonation Map for South Manchester consisting of the Newport Limestone was prepared as part of Halcrow's South Coast Sustainable Development Study - *Technical Report 4*. The map shows that South Manchester lies within the very low to low landslide hazard zone.

Rockfall

One of the two parallel geological faults passes through the Reeves Wood area (K62+500). At the foot of the hill is to be found limestone boulders of varying sizes scattered within the area. A very large boulder weighing hundreds of tons was located at the side of a house. The highway alignment passes through the side of the hill and during excavation and construction, there will be an increase in rockfall susceptibility.

The potential for rockfalls is moderate during and excavation work and following and road construction, however mitigation measures for reducing rockfalls and slides will reduce the impact of slope failures along the proposed highway.

Earthquake Hazard

Seismic data from the Earthquake Unit in Jamaica indicates that the nearest source area to the May Pen to Williamsfield highway alignment for generating damaging earthquakes is the Rio Minho - Crawle River Fault. This fault passes approximately 25km -30 km north of the project area and is associated with the Gonave micro-plate, which includes the Plantain Garden – Enriquillo Fault Zone (Figure 4.53). The Kingston Seismic Hazard Assessment Study (1999) indicates that the slip rate of the Rio Minho–Crawle River Fault is approximately 5mm/year.

Hydrogeology

The elevation changes over the length of the highway range between 40m at the eastern end to just under 400m at the western end. From Km44+000 to Km57+000 the average ground elevation is about 40m above sea-level. Beyond Km57+000 the elevation begins to increase to above 400m as the mountains are encountered just west of the Milk River.

The hydrogeology of the site comprises two distinct aquifer groups, the Limestone Aquifer to the west and the Alluvium Aquifer to the east and occupying the alluvial plains from Km44+000 to Km56+000. Groundwater depth is estimated between 5 – 20m below ground level with principal flow direct to the south.

Surface drainage is dominated by the Milk River watershed in the west and the Rio Minho and its tributaries in the east. Flow is predominantly to the south with fault-controlled flows in the limestone hills. No springs are recorded within the highway corridor; however, several temporal springs were reported during the June 2002 torrential rains particularly between 130 - 180m in elevation. These springs remained on the surface for just over 3 months before disappearing.

Sewerage Facilities

The proposed route crosses several existing houses and other properties and while there are no municipal or community sewage treatment facilities on the route the older homes would have been constructed with absorption pits as the means of sewage disposal. These pits will typically be 3 – 4 m in diameter and of varying depths of up to 5 m. More recently constructed facilities, since the 1970's, may have a septic tank and soak away.

Historic Flooding along the Proposed Route

The entire section of the highway corridor, from the Rio Minho crossing to Trinity has a long history of flooding with well documented flood prone areas due in large part to its geology and hydrogeology. There have been several significant flood incidents in the recent past. Events such as the June floods of

1986, May floods 1993, Porus (May/June 2002) and Harmons (September 2002), October 2005 and June 2011 come immediately to mind by persons in the general vicinity largely due to the ease of recall. During 2007, several residents voiced concerns about the proposed highway corridor at the time. Consequently, NROCC engaged a consultant to undertake a flood risk management study which covered fourteen communities[1] along Phase 1B and the previous alignment for Phase 1C. In order to capture the historical flood events along the highway corridor, this section of the Addendum references that report, several other historical reports, newspaper stories as well as the ODPEM Flood Registry. Flood zones were demarcated as flooding on the alluvial plains between the Rio Minho crossing to the western edge of Clarendon Park, and from the limestone hills west of Clarendon Park to Williamsfield.

<u>Air Quality</u>

The results indicate that the particulate matter (PM_{10}) concentrations on the site were within the NEPA 24 hour guideline of $150µgm^{-3}$ for each day measurements were done. The PM_{10} levels on average, were below 27 $µgm^{-3}$ for all the areas tested except for Trinity and Hope Village on day one of the assessment. Hope Village exceeded the NRCA's 24 hour standard for the cumulative concentration over 72 hours. The PM_{10} concentration at this sampling location for day one was very high when compared to other sampling days. It was observed that maintenance work was being done on the adjacent property to the sampling site. Any activities such as burning or clearing of the land will increase the levels of airborne particulates. The monitor placed at Trinity was also in an area where human activities may have influenced the elevated PM_{10} concentrations measured on day one of the assessment.

The low PM_{10} levels measured at Duke Street in Toll Gate on day two of the assessment may be due to rainfall in the area. Rain acts as a natural sink for airborne particulate matter.

<u>Noise</u>

This section outlines the results of the seventy two (72) hour noise monitoring exercise at the seven (7) monitoring stations. It is assumed that all seven noise monitoring stations are located in residential areas. The following is a summary for each station.

1. Stations 1, 3, 4 and 6 were non-compliant with the NEPA daytime guidelines.
2. Stations 1, 2 and 4 were compliant with the NEPA night time guidelines.
3. Station 2 was the only location to have night time noise levels higher than the daytime noise levels. This is possibly due to night time anthropogenic noise sources such as crickets chirping etc.

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[1] Savannah Cross, Spring Grove, Hunt's Pen, May Pen, McGilchrist Palm (St. Jago), Four Paths, Osborne Store, Inverness Gardens, Toll Gate, Free Town, Clarendon Park, Sandy Bay, Redberry, Watermouth

4. The L10 for all stations excepting for Stations 1, 2 and 6 were compliant with the Federal Highway Agency's (FHA) standard of 70 dB for the 72-hour monitoring period.
5. The L10 for stations 1, 2 and 6 exceeded the Federal Highway Agency's (FHA) standard of 70 dB for 1.4% of the monitoring period.
6. All Stations except Station 7 had noise with frequencies centred around a low frequency band (12.5 – 500 Hz).
7. Station 7 had noise centred around a high frequency band (6300 Hz), possibly due to a high frequency noise source in this area.
8. Five out of the seven noise stations had mostly moderate fluctuations in the noise climate. Stations 1 and 6 were the only two noise stations to have mostly large fluctuations in the noise climate.

<u>Water Quality</u>

The results of the water quality analyses for the surface water samples associated with the project site indicate that there is some degradation in the water quality for the samples possibly from anthropogenic activities. This is especially so for the St. Anne's Gully samples which had elevated BOD, conductivity, total dissolved solids, sulphate and chloride levels. This Gully acts as the conduit for storm water run-off and possible trade effluent from the May Pen. These water bodies also pass through well populated areas some of which have livestock or practice livestock rearing. Surface run off from these areas or discharges from anthropogenic activities will negatively impact the quality of the water in these systems.

Biological Environment

<u>Habitat types, vegetation and ecological functions</u>

The entire study area was strongly influenced by human activities and therefore highly disturbed. The vegetation zones were influenced by gradients of elevation, rainfall and disturbance, as well as geology and drainage patterns. More than 220 species of plants were encountered in the surveys (Appendix IV), the majority of these were introduced, common and widespread in Jamaica. A few endemic species were found mainly in the forested areas around the community of St. Toolis, however, this is to be expected, based on the level of disturbance elsewhere.

Alluvial plains

The composition or structure of the natural vegetation that originally characterized the alluvial plains of south central Jamaica has been totally extirpated, and there are no records of its composition. This area has historically been under intense agriculture with the cultivation mainly with sugar cane and this long term disturbance means that all of the natural or semi-natural vegetation has been removed and only remnant secondary pockets remain in fallow areas.

Clarendon was characterised by ruinate woodland on alluvium in a few small areas with species that are resistant to grazing by goats and cows; Grass pastures characterized by abandoned cane lands have reverted to Seymour Grass *Andropogon pertusus* and are used for grazing goats and cows; and sugar cane, which is grown as a monoculture in fields separated by interval roads.

Freshwater habitats

Freshwater habitats in the zone of influence of the highway alignment include the Milk River, Rio Minho and several small streams and irrigation canals. There are also some small natural ponds in the general area. The rivers and streams have dense vegetation typical of a riparian environment including large trees on their banks. This vegetation is important for protecting the integrity of the banks, reducing soil erosion and capturing sediments. The rivers include complex habitats that support a variety of fish and invertebrates. They also function as possible migration routes for various species including pond turtles. Thus it is important that the rivers and streams and their vegetation should be protected and that they should not be further channelized.

Mesic forest on limestone with scattered rural settlement, cultivation and bauxite mining

Elevation of the route increases between Clarendon Park and Williamsfield, the new alignment passes between the community of St. Toolis and the Upper Milk River Valley where Scotts Pass and Porus are located. The geology is mostly limestone interspersed with pockets of bauxite and shallow pockets of topsoil. The hills are dominated by mesic forest on limestone that are highly disturbed and of the large timber trees have been removed. Many of the depressions contain soil and these areas are usually supporting cultivation of mixed crops or larger fruit trees. Some of the valleys have been mined for bauxite.

Caves are important for many species of animals, including bats and invertebrates and often house cultural remains. They are frequent in limestone areas, and their presence might be expected in this area. However this survey found no evidence of caves in the literature, and local people did not report any caves.

Rural settlement and cultivation

The alignment corridor cuts though small cultivations and homes with well-established gardens, which include typical fruit trees including Mangoes, various *Citrus* species, Star Apples *Manilkara sapota,* Tamarind *Tamarindus indica*, Avocadoes *Persea americana* and ornamental plants such as Crotons *Codiaeum variegatum*, Ixora *Ixora coccinea* and Bougainvillea *Bougainvillea glabra* and the June Rose *Lagerstroemia indica*. Larger ornamental trees included Poinciana *Delonix regia*, Cassia trees *Cassia fistula*, African Tulip *Spathodea campanulata* and Yellow Poui *Tabebuia rufescens* are also common. There are also several small plots of mixed cultivation scattered around the areas with settlement with Cassava *Manihot esculenta* being the most common.

Several areas are currently being mined. These areas often have very deep pits with very little vegetation growing in the pits. Some pits had stands of Oil Nuts *Ricinus communis* growing inside or on the sides of the pits.

Fauna

Birds

More than 100 species of birds were observed in the study area during surveys. Twenty two of Jamaica's twenty nine extant endemic species were observed in the field in the vicinity of the alignment. These are the more common and widespread species that continue to occur in disturbed forests. None of the less common endemics that are dependent on natural forests were observed in the area and this is a strong indication of the highly disturbed nature of all the habitats along the alignment.

Reptiles

The most common reptiles were *Anolis* lizards, which were observed throughout the forests, residential and cultivated zones. Common reptiles included anoles such as *Anolis lineatopus* and *A. grahami.* Geckos *Aristelliger praesigni*s were common and were frequently detected from their calls.

The American Crocodile *Crocodylus acutus* is a globally threatened species and is therefore of special concern. Crocodiles might visit the fish ponds via the rivers and streams in times of drought or food shortage but this is probably quite rare. They are abundant in the lower reaches of the Milk River and Rio Minho but were not observed or reported in the area of the alignment but this may be due to the fact that this section of the river is often dry at Rio Minho or small and inadequate for adult Crocodiles at this section of the Milk River. They have not been reported from Porus.

The endemic pond turtle or Jamaican Slider *Pseudemys (Trachemys) terrapen* is known to inhabit the area and is common in fish ponds. Little is known of the ecology of this species. Although it is known to migrate, it is not known whether its movements are strictly seasonal or simply in response to water levels mediated by rainfall frequency and drought. The highway might be a major impediment to any such migrations, but in the absence of detailed information about the size of the local population or migration patterns in general, it is impossible to assess the impacts or determine whether mitigation measures will be needed. As a general principle it will be easier for them to move if the existing drainage channels that traverse the alignment are allowed to remain in conduits that are wildlife friendly. Based on the high risk of flood as a result of run off from the upper watershed, this would appear to be a prudent measure to reduce the risk of flood water backing up to the north of the highway.

Amphibians

Cane Toads *Bufo marinus* have been observed throughout the area. This alien invasive species was more common in moist areas. Other frogs were heard during evening visits to the site, the most common was the introduced, invasive Johnsons Robber Frog *Eleutherodactylus johnstoni*, which was very abundant in the wooded areas and gardens. The Laughing Frog *Osteopilus brunneus* and the Jamaican Snoring Frog

Osteopilus crucialis were also detected during evening visits to the area. These are common in moist mid-level forests particularly in areas with abundant tank epiphytes such as *Hohenbergia* sp..

Mammals

The only mammals observed in the study area were the Small Indian Mongoose *Herpestes javanicus,* Brown Rats *Rattus norvegicus* and at least two species of bats. Bats were not abundant at any of the nocturnal bird survey points. The presence of the endemic Jamaican Fig-eating Bat *Ariteus flavescens* might be predicted for the area. This species does not roost in caves.

Aquatic animals

Observations of the offerings of roadside vendors indicated that the most common shrimp in the river is the introduced Red Claw (*Cherax quadricarinatus*). This was confirmed by discussions with the vendors who reported that native shrimps have become uncommon. At least one species of mosquito fish 'ticky-ticky' fish (as yet unidentified) were seen in the river.

Keystone species

Keystone species on the alluvial plains include the large Guango trees, which provide food and a refuge for many species of birds and insects. In the forested areas, large Cedar, Silk Cotton and Fig *Ficus spp*. trees are of special ecological importance, as are the Zebra butterflies and their *Passiflora* food plants. Large birds particularly pigeons, especially the White-crowned Pigeon *Patageionas leucocephala*, play an important role in seed distribution in the forests.

<u>Threatened and endangered species</u>

Plants

The road corridor passes through highly disturbed alluvial plains (which were converted for sugar plantations hundreds of years ago) and limestone uplands (which have been disturbed by cultivation, selective harvesting of timber and sticks and grazing). Both areas support many non-native and invasive species. The sites that are most likely to support threatened species of plants are the freshwater streams and canals, and the less disturbed areas of mesic forest on steep slopes and rocky hill tops. However no threatened plants were encountered. Species of interest include *Portlandia*, a Jamaican endemic genus, which is yet to be rated by IUCN but is expected to be categorized as threatened, based on its limited range.

Birds

Only 22 of Jamaica's 29 extant endemic species were encountered during the visits although a few more may occur occasionally the rarest species which are often the most dependent on natural or old growth forests are largely absent. No threatened (IUCN) species were present.

Amphibians and reptiles

The Jamaican Slider is classified as Vulnerable by IUCN. American Crocodile is Vulnerable and a protected species in Jamaica. Although they were not observed during the survey but they are expected to occur. The Jamaican Snoring frog is listed as endangered (IUCN) and is locally common in the area.

Other species

Several species of Butterflies were observed but none all species identified were common and widespread in similar habitats island-wide. Some were endemic to Jamaica but were not endangered e.g. *Battus polydamus*.

Socio-Economic Environment

The Zones of Impact

Collectively, the communities crossed by the alignment or close to it, define zones within which immediate and cumulative project impacts or degrees of same, will be experienced. However the impacts of the project will permeate well beyond these limited zones, particularly the travel time reduction impacts and the development generation effects.

Special attention was paid to the following zones that fall into these spatial classifications.

- The 1km buffer zone around the alignment.
- The 2km buffer zone around the alignment.
- The 3 km buffer zone around the alignment.

Special attention was also paid to:

- The ED’s through which the alignment passed.
- The ED’s immediately adjacent and contiguous to the ED’s through which the alignment passed.

Based on a Google determined assessment, the Consultants placed the following communities into the 1 to 2km project zones, which are considered to represent the most immediate impacts, particularly construction dislocation.

Clarendon

1. Content Village
2. Four Paths
3. Osborne Store
4. Clarendon Park
5. Decoy
6. Toll Gate

Manchester

7. Scott's Pass
8. St. Toolis Lower
9. Porus
10. St. Toolis Upper
11. Melrose Hill (Vendors)
12. Royal Flats/Willamsfield Gardens
13. Williamsfield
14. Hope Village
15. Melrose

The total number of interviews conducted during the rapid appraisal survey was 300 persons in the above listed communites. This was considered to be sufficient to bring into focus those positive or negative impacts that the communities and stakeholders are likely to perceive. Population data for these communicates are presented in the following section.

Present and Projected Population

Current and projected population estimates within the selected buffer zones of the alignment are presented in the table below.

Table: Population by Buffer Zones and Population Projections 2011-2030

2011	**2015**	**2020**	**2030**	**2035**
1km Buffer Zone				
15,389	17,168	20,282	23,840	26,063
2km Buffer Zone				
45,322	50,561	59,729	70,208	76,757
3km Buffer Zone				
78,199	87,239	103,059	121,138	132,438

The assumption used is that the population growth rate will continue at a rate similar to its most recent 10 year annual average rate. STATIN's population projections by parish may differ as more sophisticated forecasting models are used. No official projections are made below the parish and parish capital level. An early request to STATIN for population projections from 2011 to 2035 has not yet been provided. If received, they will be incorporated into the final report. The approach used, limits population increase to a recent historical trend and does not factor potential in-bound migrations due to projected H2k induced developments.

The demographics of this population is likely to reflect that of the respective parishes in that typically 50% of the population will be females and 50% males.

Land Use

After crossing the Rio Minho the alignment moves through a significant area of former agricultural sugar cane lands. Currently these reflect the uncertainty of sugar production in Clarendon as these lands mainly comprise degraded pasture land and uncultivated holdings with stretches of commercial agricultural production. Chicken farming is an important land use activity with several medium size chicken holdings. Interspersed within each buffer zone both to the north and south along current roadways are linear roadside communities comprising a mix of housing types and commercial activities. The communities of note are Content Village, Denbigh, Four Paths, Osborne Store, and Clarendon Park. Business losses, due to traffic diversion, are foreseen by communities such as Osborne Store and Clarendon Park. Residential land use is however, relatively low density.

The alignment itself does not significantly alter land use in this part of the alignment although it does impact some residential, religious, commercial and farming structures. Neither does it fragment communities or infringe significantly, social right of ways. This latter is elaborated on below.

Once the alignment leaves Toll Gate in Clarendon it crosses the Manchester border to the south west of Scott's Pass and ascends through elevated hilly areas to traverse Lower St. Toolis to the south, Porus to the north and Upper St. Toolis to the south. The land use becomes mainly forest land interspersed with pastures, mining activity and infrequent settlements.

When buffer zone 3 is assessed, section of May Pen (Bushy Park) and a section of Mandeville (Heartease) are included.

Economic Activity and Livelihood within the Buffer Zones

The buffer zones can be viewed as boundaries within which economic activities take place and define general zones within which any benefits of the highway to communities adjacent to it will be experienced. Understanding these economic benefits and how they are likely to be distributed among the zones are key considerations.

The starting point for this analysis is the ranking of overall community economic activity by the 300 respondents in the rapid appraisal survey.

Table 0.1: Most Frequently Ranked Economic Activity by Community Members

Respondents = 300	**1st Ranked**	**2nd Ranked**	**3rd Ranked**
Community Members	Agricultural	Retailing	Entertainment & Micro services
Business Persons	Agriculture	Retailing	Micro services

The highway is expected to improve the transportation of produce from the hinterlands of both parishes to main regional markets. Some evidence of this is seen at the beginning of the Melrose Bypass at the Williamsfield end.

A primary objective of the Highway is to create travel time savings. Exported/ imported/ more cultural exchanges in a context in which community members identify entertainment as an important income source.

Increase employment opportunities by widening the labour market catchment area.

The main economic activities along the alignment can be generally characterized as:

1. Business operations (small and medium mainly, but including a few large) covering sectors such as food and clothing retail, laboring including farm labour, entertainment, mining and transport.
2. "Higglering" and hustling.
3. Professional services.

Typically, all communities have evolved with little planning inputs other than the sometimes required building codes approval. Many building additions escape this requirement. Hope Village Royal Flats and Williamsfield Gardens are the exception, being planned housing developments. In the remaining communities unplanned features appear to dominate.

<u>Planned Development Activities</u>

Based on the interviews conducted, there appear to be no major developments planned for the sections of Clarendon that the highway alignment will impact. In Manchester, however, a number of projects were highlighted. These include development in and around the Broadleaf community which lies within the 2km buffer zone of the alignment, to the south west of Porus. This area is also near to bauxite mining zones, and is slated for residential development through JAMALCO, as well as part of a NWC project to realign a distribution pipe from Porus to Mandeville through Broadleaf. In addition to this, a 1,000acre mixed commercial and residential NHT development is slated for the area Mount Nelson into New Hall. Also mentioned were plans to develop the current Melrose Yam Stop into a TPDCo tourist Rest Stop. It is not clear whether these developments will impact the alignment.

<u>Squatting and Resettlement</u>

Although most communities within the 3Km buffer zones suffer from some degree of poor housing stock, traditional squatter type communities are absent. An important feature of the adjustments made to the original alignment for this 2C phase is that resettlement issues have been minimized.

An important consideration in Highway development is the impact of the roadway on pre-existing roadways, rights-of-way and field crossings. The Consultants were able to do a high degree of due diligence through ground verification of the alignment, to satisfy themselves that adequate provision had made for crossing the alignment and no major issues were identified.

NROCC and bauxite mining interests are in ongoing discussions, which will presumably resolve any issues relating to mining rights.

Some of these issues have traditionally arisen at the Public Consultation and will therefore be reported on in the final report, following these consultations in early February.

Community Characteristics

The main purpose of the socio-economic component of this EIA is to discern the impact of the project on the near communities and the likely impact of the near communities on the project.

As a general opinion, the Consultants expect that the impacts of the project will mainly be experienced by the communities and the communities will have very little impact on the project.

Further it serves no special purpose to describe these impacts on a community by community basis. Where a particular impact is centered on or of special significance to a specific community this will be highlighted. The approach adopted is to start with Table 4.16 which captures general community characteristics and then address the commonality of impacts that the highway may have on these communities and the special impacts that some communities may experience.

Summary of Important Characteristics of Near Communities

The project is linear, and traverses a significant length of Clarendon and almost half the length of Manchester as measured along the A1 main road. It therefore passes close to a number of settlements that are unique in specific ways but fairly typical across a variety of typos.

They are mainly middle and lower income earning communities. Their main income source derives from retailing activities and agricultural production. Also micro services were defined to include household skills, building skills, community services such as personal care services, and labouring. To the extent that main sectors are important sources of employment, these would be sugar estates and bauxite, across parish lines. The communities are unplanned in a formal sense though they do come under some planning interventions and regulation, by local authorities.

Perceptions by Communities

Near communities perceptions of themselves is also fairly consistent. With one exception, their populations are all seen as growing. In the very high majority of communities unemployment is characterized as high or very high. Social services are mainly described as adequate or good, but many communities pointed to poor service in specific instances.

Community members' approval of the project was consistent and favourable, although every community had its dissidents.

Public Health and Community Health and Safety

Waste management services are provided by the MPM Waste Management Limited in Clarendon and SPM Waste Management Limited in Manchester. They serve all of the near communities.

These communities are also served by a limited number of health centers, one Type B Regional Hospital in Clarendon, one Health Centre in Porus and one Type B Regional hospital in Mandeville, Manchester.

Cultural Aspirations and Attitudes.

This was probed in all communities using the rapid appraisal survey. When tabulated, the 3 responses most frequently ranked were: 1) the desire for improved employment opportunities, 2) an increase in personal income and 3) the desire that their community achieved prosperity. These aspirations and attitudes would be a prerequisite for taking advantage of the highway.

Heritage

Archaeological and historical records in the project area the area within the vicinity of the proposed highway contains sites dating to the Taino and the Spanish. The subsections below elaborate on heritage features of note within the 2km buffer zone only. Heritage features outside of this area are not considered critical due to distance and impacts are not likely based on the nature of the development. Outside of these above-ground features, it is important to note that heritage elements can also exist underground and as such during excavation, it is likely that old relics may be found.

The British is well represented within the 2km buffer zone of the project area with several sugar estates dating to the 18th century at such places as Clarendon Park and St. Jago. There are district heritage features near the alignment but few of these above ground actually exist within the 2km buffer zone from the alignment and no above-ground elements were identified within the path of the alignment. Underground relics may exist due to the presence of slave villages and so protection of any artefacts found during excavation would be critical.

CUMULATIVE IMPACTS

Cumulative impacts are largely ecological and social. With respect to biological issues, road kill of birdlife, fragmentation and loss of habitat, particularly in the mesic limestone forested areas are long term issues. Additionally, the burning of sugar cane may negatively impact vehicular traffic particularly in the Four Paths, Osborne Store and Toll Gate communities.

It is anticipated that traffic along the highway will increase over the years. Given the highway, opening up the area to greater ease of traffic, targeted land use planning is required to ensure sustainable development options. Currently, agriculture, residential and commercial are the main land uses, but this can change which greater access.

Employment is also another cumulative impact anticipated. The construction phase for the highway is scheduled for 30 months and will require various levels of skilled and unskilled labour as well as the provision of goods and services. The other phases of Highway 2000 have created job opportunities, and this would be continued over the medium term.

IMPACTS AND MITIGATION

Several potential negative impacts have been identified for the physical, biological and socio-economic aspects of the environment. Issues were identified and related to sources of aggregate; the alignment; sedimentation, drainage and flooding; blasting; cut and fill and slope stability; air quality; noise; traffic and equipment management; loss of species; worker safety; heritage; solid waste management (construction spoil and vegetative waste); sewage waste management.

Mitigation measures have been identified and presented to minimize these negative impacts as shown in the table below.

Table: Summary Impacts and Mitigation

Activities/ Main Issue	Possible Impacts	Mitigation Measures
	Construction Phase	
Purchase of sand and quarry aggregate such as from rivers	• Improve the economic viability to the project when material can be sourced cheaply because of proximity to the project activities. This eliminate importing material. • Increase in employment of workers in the river aggregate industry.	-
	• Strong demand for river aggregate by highway construction could create material shortage for other stakeholders. • Illegal quarrying could be increased due to shortage. • Disruption in traffic due to haulage of raw materials.	• Manufactured sand and gravel could be exploited by other users in the construction industry as an alternative to river sand/gravel. • MGD should monitor for illegal sand mining. • Limestone aggregate for road bed fill should be sourced from a quarry south of highway to prevent haulage across A2 main road minimizing traffic disruptions.
Limestone aggregate from excavation as fill	• Large purchase of fill obtained from excavation in the hills of St. Toolis, Reeves Wood and Melrose Hill, reducing construction waste on project.	-
	• Material for May Pen to Clarendon segment can be source within short distance from construction activities.	-

Activities/ Main Issue	Possible Impacts	Mitigation Measures
	• If limestone is sources at the northern side of the main road between May Pen and Clarendon Park, then traffic congestion will likely increase	Mitigation measures elaborated under transportation below.
	• Dust from haulage of trucks travelling from source to construction site	Mitigation measures elaborated under transportation below. Wetting of roads should be done regularly e.g. preferably 30 minutes and in accordance with best practice.
	• Some community members can be hurt by haulage trucks.	• Appropriate signage to prevent persons in restricted area and to facilitate detours as necessary. • Ensure appropriately trained drivers.
Alignment hindering bauxite extraction	• A section of the alignment will pass through large bauxite deposits in the mining lease area operated by Jamalco. Namely: Redberry, Reeves Wood	• Discussions with JBI to have a smaller impact so that only a few smaller deposits can become sterilised during negotiation. • Highway should be shifted to the north east to avoid larger reserves in Redberry and reeves Wood based on site visits by both JBI and Highway developers. • Where sterilisation is unavoidable, Jamalco reserves the right to mine out and stockpile any deposits on the north east side of the alignment. • Access to mining on the north east of alignment should be created and not blocked.
Construction activities blocking sinkholes	• Potential blocking of sinkholes leads to flooding and prevention of storm water to recharge the aquifer.	• Detailed design during the design phase to protect against blockages. • Excavation of soft material to a depth specified by geotechnical engineer. Enlarge sinkhole as necessary to allow for installation of the filter material. • Place non-woven geotextile at the bottom of excavated material and placement of boulders (100/300mm rip-rap)
Cut and Fill	• Cut and fill activities will result in a surplus of excavated material that will need to be disposed of appropriately.	• Identify an appropriate and approved site for disposal and management of excess material. • Identify other projects that may require fill

Activities/ Main Issue	Possible Impacts	Mitigation Measures
		material. • Spoil tips for construction waste should be kept as close as possible to the project site and secured to prevent erosion. • Use surplus for landscaping
	• Landslides are potential impacts in some areas, specifically: tributary of Milk River in St. Toolis; geological faults in Reeves Wood and Melrose Hill Bypass that are susceptible to rockfalls and slides; in St. Toolis where deep cuts are to be excavated in karst limestone	• Slope stabilisation mechanism to be implemented especially in these specific areas e.g. earth retaining walls. • The landslide area in St. Toolis (along tributary of Milk River) should be avoided. • Use of benched slope in susceptible areas. • Reduce slope angle by cutting back.
Blasting	• Damage to residential dwellings due to blasting vibrations and rock fly in close proximity to blast sites. A residential dwelling located on the foot of the hill in Reeves Wood; residences in the southern section of the town of Porus. • Damage to persons nearby	• Conduct a pre-blasting survey. • Peak particle velocity vibration should not exceed 25 mm/sec. • Detonation for each row of blast holes delayed by 8 milliseconds. • Stemming of the blast drill holes should be sufficiently deep to dissipate blast energy within ground rather than above ground surface. • Appropriate safety and protective gears for workers
	• The blast energy results in mobilisation of loose limestone on slopes and earthquakes causing potential damage to structures e.g. bridges, secondary roads etc. • Slope failure of unprotected embankments and high road cuts, especially in fault zones.	• Experienced blast contractor with insurance hired. • Blast warning signs to be erected. • Proper management of blast sites. • Seismographs used where necessary to monitor explosions. • Seismic designs to be included as part of the design principles for the highway e.g. IBC code/international seismic code • Slide protection measures to minimize impact of shaking • Develop earthquake hazard plan.
Sediment runoff and flooding during construction	• Clearing of land • Improper storage of fine earth material near to drains and or stream • Damage to aquatic ecology and/or	• Incorporate into design appropriate non-structural practices to minimize erosion. • Develop an Environmental Protection Plan for which a major component is an erosion and sedimentation control plan.

Activities/ Main Issue	Possible Impacts	Mitigation Measures
	flooding problems • Pollution from leaching of construction spoils	• Erosion and sediment control measures and best practices should be put in place starting from the design phase as elaborated in Section 6.1.1.2 above (e.g. sediment traps, filter fabric fence, vegetated filter strips, grassed swales.
Disruption of surface water and water quality (WQ) a. Changes in hydrologic regime	• Improper storage of construction material or refuse • Removal of exiting natural drains without appropriate alternatives • Damage to aquatic ecology and flooding	• Proper storage of construction material e.g. cover stockpiles with tarp, drainage paths diverted away from stockpiles. • Proper storage of hazardous materials. These should be lock away when out of use as instructed by material safety data sheet (MSDS). Develop and implement a chemical control management plan. • Erosion control measures as outlined in Section 6.1.1.3 above will minimize sedimentation discharges into the many streams, gullies and rivers. • Monitoring of effluent and discharge points during construction to help keep matters in check.
Water supply disruptions due to existing distribution pipelines in areas along the alignment.	• Water supply from wells in Clarendon for domestic supply and irrigation. Potential damage to pipelines constrained to existing roadways. • Cut off of water supply to communities.	Relocate pipes out of the construction zone of the highway and relocation of existing roadways will mean that a "sleeve" should be installed and the pipeline inserted through the "sleeve" to allow for access to the pipeline without entering the wayleave of the highway. This will reduce risk of damage and cut-off from supply.
Range of activities outlined (blasting, cut and fill etc.) above resulting in poor air quality (AQ)	• Poor air quality impacting residents of nearby communities especially: Four Paths, Osborne Store, Toll Gate, St. Toolis Reeves Wood, Redberry and Porus	• Dampening of exposed surfaces during dry periods should be implemented as part of the site activities during construction. • Covering of stockpiled fine material. • A phased approach should be undertaken during construction to limit the time locals are displaced. • Limit the hours of noisy activities between 7am and 6pm • PM10 be monitored in µg/m3 using the WHO's ambient air quality guidelines during the construction period. • Develop implementation plan to guide construction activities.

Activities/ Main Issue	Possible Impacts	Mitigation Measures
Noise and vibration nuisance from construction activities	• Nuisance and potential hearing damage to nearby residents and workers. • Other health risks triggers from sustinaed high noise levels.	• It may be useful to monitor noise during activity to ensure that decibel is restricted to 70dBA or below of sustained noise which is detrimental to human hearing. • Advise neighbouring properties at least 24 hours in advance of planned noisy activities. • A phased approach should be undertaken during construction to limit the time locals are displaced. • Limit the hours of noisy activities between 7am and 6pm • Develop implementation plan to guide construction activities. • Monitoring of noise during construction to help ensure levels in kept check. • Consider temporary noise barriers where communities are more densely populated.
Biological impacts due to land clearing	• Most sensitive ecosystems on the alluvial plains are freshwater river, ponds, streams, canals, which support the Jamaican Slider and fish, along with rare aquatic plants are sensitive to restrictions in water flow and sedimentation. Death in aquatic life can result. • Changes in drainage and sedimentation can also impact the stability of coastal mangroves.	Sediment control mechanisms as already discussed above.
	• Removal and trees and excavation of hillsides will lead to direct loss of species and disruption in drainage. • Disruptions may lead to change in land use and use of natural resources of the forest.	Sediment control mechanisms as already discussed above.
	• The alignment through the upland forest will likely result in changes in connectivity, humidity, migration of species and conduit for invasive species. The area is, however, already fragmented.	-

Activities/ Main Issue	Possible Impacts	Mitigation Measures
Worker employment	• Generation of employment during construction activities for local community residents	-
Worker safety	• Accidents and adverse effects on workers may occur on construction sites	• Worker safety should be protected and safe practices implemented. • Wearing of the appropriate protective gear on site should be stipulated and mandatory. • Sanitary practices in regard to providing potable water and the disposal of human waste should be enforced to safeguard worker health. • Construction crews should be provided with the appropriate safety gears such as hard hats, gloves, safety shoes, reflector vests where appropriate, etc. • Appropriate signage on site to prevent unwanted persons being put at risk.
Traffic congestions due to detours and transportation by heavy duty trucks of material – sand and gravel etc.	• Road detours and congestion and nuisance to several communities – Four Paths, Osborne Store, Toll Gate, St. Toolis Reeves Wood, Redberry and Porus. • Changes in traffic type and volume are expected to negatively affect traffic flow when heavy vehicles are entering and leaving the construction site to deliver materials and equipment. • Potential dust nuisance arising from transporting light material (AQ mitigation measures already outline above) • Damage to roads and road furnishings, curbs, bridges culverts and poles. • Potential for Personnel accidents and other human vulnerabilities arising from heavy duty vehicles on roads	• Trucking material on site during off-peak periods. • Appropriate signage during construction. • Ensure that trucks are not overloaded to prevent road damage • Ensure that trucks carrying fine material are properly covered to ensure that material does not litter the road or cause a dust nuisance or damage to pedestrians or housing and business along the truck route. • Ensure that road rules are followed, drivers are qualified, and that trucks are not over the load limit to reduce risk of accidents.
Placement and use of equipment	• Potential dust nuisance to residents nearby construction works (AQ mitigation already outlined above) • Equipment usage onsite will likely result in high noise levels for an	• Inspect (daily) all vehicles and equipment for potential leakage of fuel, oil, hydraulic fluid or coolant. Any machinery found to be leaking will be repaired or replaced. • Vehicles and equipment used should be

Activities/ Main Issue	Possible Impacts	Mitigation Measures
	extended period Potential noise nuisance to residents nearby construction works (Noise mitigation already described above) • Contamination of nearby rivers and drains	serviced to reduce noise levels. • Standard operating practices for construction should be adhered to: E.g. restricting the time of day that such activities (during work hours)[2]. • Hazardous materials such as fuels and oils should not be stored near storm water drains. • Provide appropriate signage and security for all storage of dangerous goods. All incompatible materials will be segregated. • Provide Material Safety Datasheets (MSDS) for dangerous goods used or stored on-site. Personnel will to be made aware of the environmental and safety requirements for these hazardous materials.
Solid waste disposal	• Construction waste material, and other domestic waste that would be generated on site are to be appropriately disposed. • Poor solid waste disposal pose a health risk. • Poor solid waste management can result in blocked drains and flooding during rainy periods.	• Refuse bins should be placed on site to meet the needs of the workforce • Arrange for the collection of solid waste by certified contractors and disposal at an approved site • Any hazardous waste should be separated and stored in areas clearly designated and labelled • Open burning of solid wastes should not be conducted as these generate polluting emissions which cannot be controlled effectively. • Garbage storage area should always be kept clean. • If a bin is damaged, the contents will be transferred to another container in good condition. • The waste container should be of waterproof material to prevent the escape of fluids. • The stored waste should be covered to prevent

[2] World Bank has a 55 dBa daytime limit and a 45 dBa night-time noise limit for residential areas and a 70 dBA limit for commercial and industrial areas for both day and night time.

Activities/ Main Issue	Possible Impacts	Mitigation Measures
		rain water from flooding the waste and overflow.
Sewage treatment	• Improper sanitary facilities pose a health risk. • Disposal of improperly treated or untreated sewage • odours • Contamination of water with pathogenic organism. Spread of water borne disease • Eutrophication of receiving water bodies • Damage to aquatic ecology	• Construction camps and work areas must be adequately equipped with portable chemical toilets. • Portable chemical toilets must be provided, maintained and removed by a certified contractor to mitigate inappropriate disposal.
Potential loss of historical artefacts particularly underground during excavation and blasting	Despite the lack of visible archaeological/cultural remains, due to the historical uses of the site, there may be a possibility of encountering such remains, though limited.	• Contractors during excavation should be alerted to report any find during the construction process, in the event that excavation disturbs a deeply buried site. • A provision for chance-find should be made and the procedures to be followed in the event of an occurrence should be communicated to the contractors
Operation Phase		
Drainage and surface run-off resulting in flooding and poor water quality	• Sediments from areas without foliage • Quality of receiving waters negatively impacted by washed down oils, fuels and accidental spills from roadway. • Flooding, infrastructural damage, siltation of receiving waters • Blockage of sinkholes and	• Drainage constructed at appropriate size. • Since flooding is likely, a design life of 50 years is proposed for the highway, 10 years for minor crossings and 100 years for the Rio Minho and Milk River. • Determine and implement sediment control measures for each sub-catchment to reduce flow velocity. • Assess scour potential and if required, rip-rap lining or another form of suitable protection should be employed. • Trash screens to hinder highway garbage. • Grassed swales to promote run off infiltration and reduce exit velocities. • Monitoring of effluent and receiving water bodies. • Other pollution control measures as

Activities/ Main Issue	Possible Impacts	Mitigation Measures
		elaborated in Section 6.2.1.1.
Water supply disconnections	• In cases where the NWC pipeline falls within the highway reservation fence. Should there be breaks in the line in need of repair, permission would be necessary for them to enter the restricted area. This delay can lead to unnecessary loss of water and potential localized flooding if remains unchecked for an extended period of time.	• Relocation of pipelines within highway alignment. • Place the pipeline in a sleeve, which will allow the pipe to be extracted and repaired without entering the wayleave.
Increase in air pollutants and dust along the Highway alignment	Adverse health impact contractors, employees, residence and animals etc.	Air quality monitoring at intervals over time
Increase in noise from traffic in densely populated areas	Adverse health impact to nearby persons living in residences.	• Erection of noise wall in densely populated areas only • Noise monitoring at intervals over time
Employment generation	• Generation of employment during operation activities for local community residents.	-
Highway extension and traffic	• Reduction in traffic on A2 main road. • Reduction in time travel due to avoidance of congested communities.	-
Highway extension and social benefits	Housing and commercial developments increases in Clarendon as commuting time East West decreases, saving travel time. Communities listed below may have these impacts: • Osborne Store • Clarendon Park • Toll Gate • Scott's Pass • Porus Noise and air pollutions rom traffic along the A2 main road, decreases.	Encourage housing and commercial development in these communities as a means to help resolve Jamaica's housing and development needs. This favours Land Use planning objectives for Jamaica. Exit located at Toll Gate is suited for the area.
	The highway is regarded as safe when compared with accident reports for the normal road surfaces.	-
	Highway will contribute to the distribution	-

Activities/ Main Issue	Possible Impacts	Mitigation Measures
	of income goods and services due to improved travel time for commerce and individual enterprises.	
	The Highway will improve travel time and encourage more recreational visits to attractions in Manchester and St. Elizabeth.	-
Highway extension and Melrose Hill Bypass	Safety of vendors along Melrose Hill Bypass has negative impacts and so the developers plans to relocate these vendors is positive.	• Relocation of vendors along the Melrose Hill Bypass preferably at the end of the toll road at Williamsfield.
Community impact on highway	Contribution of vehicular traffic on the highway from communities in both Clarendon and Manchester.	-

MONITORING

Monitoring is important to reduce the negative environmental issues raised above. If a permit is granted for the realignment of the highway May Pen to Williamsfield, a full Monitoring Plan should be prepared and submitted for the approval of NEPA. This Monitoring Plan should cover the following components and over the entire construction period.

1. Inspection protocol
2. Parameters to be monitored, which should include
3. Construction monitoring
4. Materials handling and storage
5. Covering of haulage vehicles
6. Transportation of construction materials
7. Deployment of flaggers and signposting
8. Storage of fines and earth materials

1 INTRODUCTION

1.1 PURPOSE

Environmental Solutions Limited has been contracted by the National Road Operating & Constructing Company (NROCC) to update the Environmental Impact Assessment (EIA) for the realignment of Highway 2000 (H2K) East-West, Phase 1C: May Pen to Williamsfield. This EIA serves as an addendum to the EIA conducted in 2007 for Highway 2000 Sandy Bay to Williamsfield.

The Government of Jamaica implemented the Highway 2000 Project to meet the rapidly growing road transport needs of the country by establishing a safe and efficient motorway axis linking Kingston westward to Manchester, and northward to St Ann. The rationale for the Project stated then was to "improve the transport infrastructure of Jamaica after a period of under-investment" and thus provide stimulus for economic growth (Source: NROCC, 2016)

This report is intended to guide the execution of the realignment. Section 1 presents the details of the project; Section 2 summarises the policy and legislative review; the methodology is described in Section 3; and Section 4 describes the existing environment. Assessment of the potential impacts and recommended mitigation measures are presented in Section 5, cumulative impacts in Section 6, and the analysis of the alternatives in Section 7. A monitoring and environmental management plan is presented in Section 8.

1.2 PROJECT DESCRIPTION

This subsection describes the details of the proposed highway development. It examines the key elements involved in the project as indicated by the developer, NROCC.

1.2.1 The Alignment

The May Pen to WIlliamsfield segment of H2K is a part of the Sandy Bay to Williamsfield corridor that received an Environmental Permit in 2007 (Figure 1.1). The permit was granted following the conduct of an Environmental Impact Assessment (EIA) and submission of the requisite Permit Application Forms. The previous EIA highlighted several potential impacts that constrained effective construction and operation of sections of the proposed corridor. NROCC has subsequently reviewed the alignment, and the rationale for the deviation from the original route reported on in the 2007 environmental impact assessment (EIA) is elaborated in Table 1.1 below.

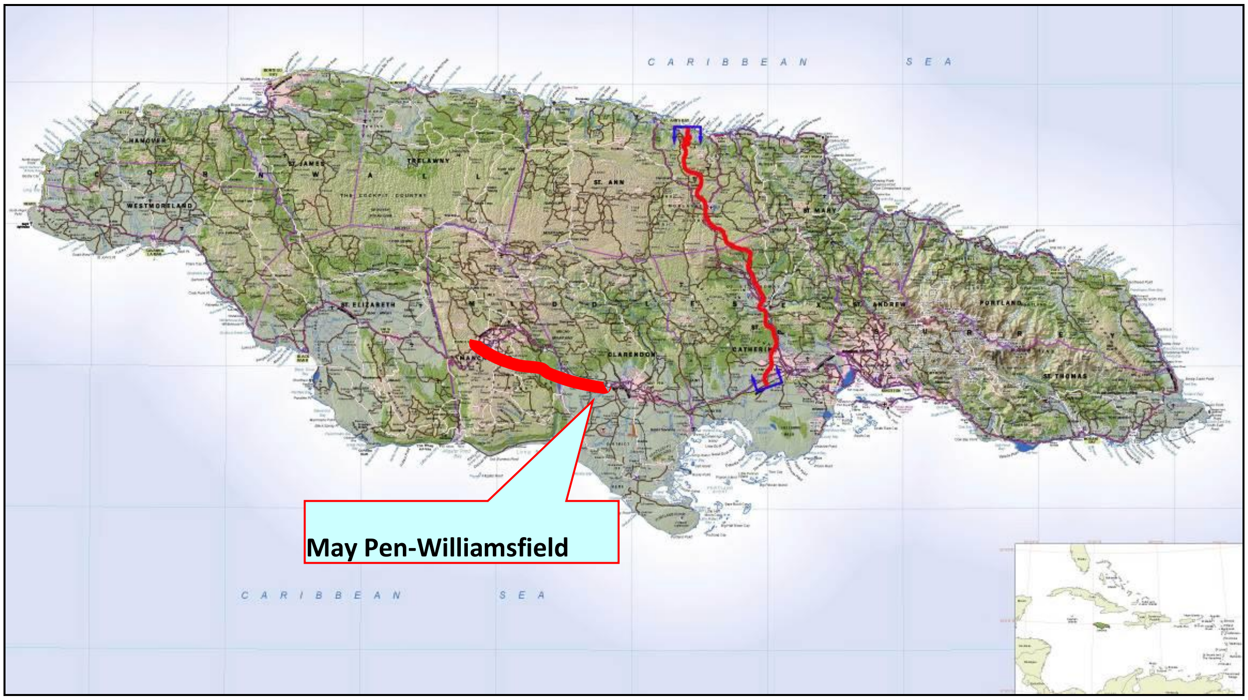


Figure 1.1: Schematic Diagram of Highway Route May Pen to Williamsfield (Source: NROCC Project Description, 2016)

The alignment of Phase 1C (**Figure 1.2**) begins at chainage K43+500 and crosses the Rio Minho bridge just before K44+000. The alignment continues westerly and the realigned section phase starts at K48+000 which is 5km west of the start point (K43+500). The road continues in a westerly direction and traverses south of and parallel to the existing A2 main road (Bustamante Highway) and south of the major communities of Four Paths, Osborne Store, Toll Gate, and Clarendon Park. The highway continues westerly and through the community of St. Toolis. The design speed for this segment of the highway will be 110 km/h.

Unlike the original alignment, the highway traverses through cane lands south of the Juici Factory and Restaurant at Clarendon Park and south of Scott's Pass, crosses the Milk River (at K59+000) and travels through the community of St. Toolis. At the entry point of St. Toolis (between K58+500 and K59+000), the alignment continues through hilly terrain and will have a design speed limit of 80 km/hr. The highway will pass through the northern sections of Reeves Wood and will cross the main road in the Redberry community. Passing through Porus, the highway will cross the Trinity main road, just north of where the trainline crosses that road. It then continues north-west incorporating the existing Melrose Bypass, and crossing the existing railway before joining the main road just south of the Williamsfield roundabout. A vertical gradient of 6% is required between St. Toolis and Williamsfield to achieve a change in ground level of almost 100 meters.

The realigned segment ends at K67+500 and joins the existing Melrose Bypass, which will be incorporated into the new alignment, upgrading to a four-lane dual carriageway with a speed limit of 80 km/hr, crossing the railway line at K71+000, before terminating just east of the Corrugated Metal Pipe bridge (CMP) or "pipe arch" in the vicinity of the roundabout at Williamsfield (K71+770). The entire Phase 1C alignment is 28.267km long and the length of the realigned segment is 19.5km.

Table 1.1: Rationale for the Deviation (Source: NROCC, 2016)

Current (Approved) Alignment	Proposed Alignment
→ **Approximately 120 residential units to be relocated**	→ Approximately 30 residential units to be relocated
→ **Dissecting and reducing the Scott's Pass community to fewer houses**	→ Bypassing densely populated communities originally impacted
→ **Construction of two (2) very large bridges crossing Rio Minho and Milk River**	→ Construction of one (1) large bridge over Rio Minho
→ **Relocation of several hundred meters of irrigation canals**	→ Small section of irrigation canals to be realigned
→ **Major construction activities in the several communities in the Porus area**	→ Construction to take place in canefields, abandoned pastures, scrub and disturbed limestone area, and woodlands
	→ Construction in mainly rural unoccupied lands

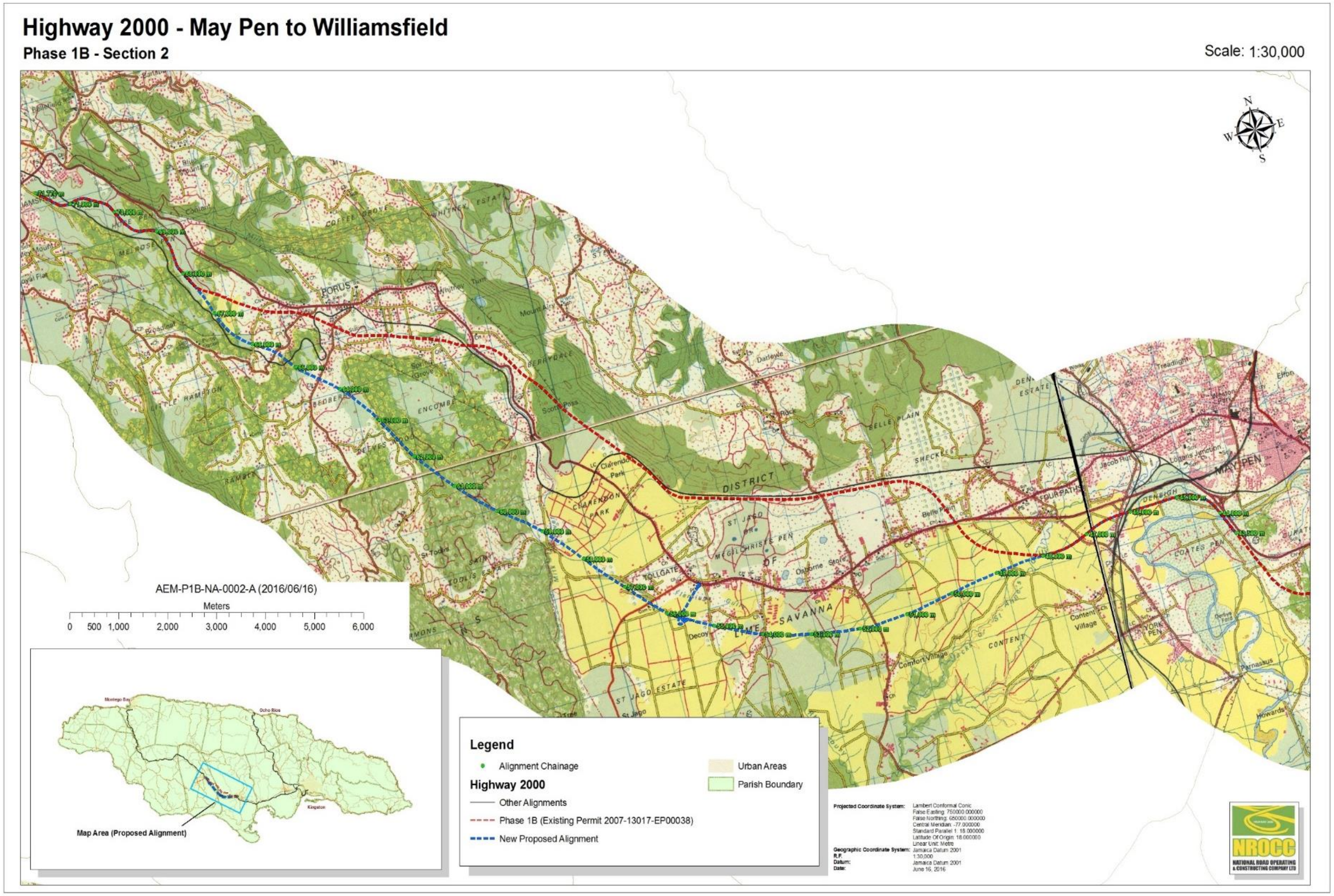


Figure 1.2: Highway 2000 Realignment of May Pen to Williamsfield (Source: NROCC, 2016)

1.2.2 Crossings

A total of fifty three (53) crossings have been identified and will be facilitated by overpasses and underpasses (Table 1.2). These crossings include rivers, local roads, and field connectors, small drains streams and rivers. In some instances, field connectors could be combined to reduce the number of crossings. This will be confirmed in the outline design.

Table 1.2: Type and locations of some Crossings and Structures along Phase 1C (Source: NROCC, 2016)

Nº	Chainage	Local Name	Underpass	Overpass	Crossing/ Bridge Type
1	**44+200**	**Rio Minho Bridge**		X	River
2	45+600	Field Connector		X	
3	46+020	Drainage		X	
4	**46+485**	**Foga Road**	X		**Railway Bridge**
5	47+100			X	Drainage
6	47+493	Denbigh Road Bridge		X	Local Road
7	48+987	Four Paths 1	X		Drainage
8	49+227	Four Paths 2	X		Drainage
9	49+527	Four Paths 3	X		Drainage
10	49+692	Four Paths 4	X		Drainage
11	50+144	Four Paths 5	X		Drainage
12	50+600	Four Paths 6	X		Drainage
13	51+130	Four Paths 7	X		Drainage
14	51+566	Four Paths 8	X		Field Connector
15	52+010	Content Road	X		Local Road
16	52+150	Four Paths 9	X		Drainage
17	52+580	Four Paths 10	X		Field Connector
18	52+830	Four Paths 11	X		Drainage
19	53+230	Osborne Store 1	X		Drainage
20	53+760	Osborne Store 2	X		Drainage
21	54+040	Osborne Store 3	X		Drainage
22	54+160	Osborne Store 4	X		Drainage
23	54+320	Osborne Store	X		Local Road
24	54+580	Osborne Store	X		Drainage

Nº	Chainage	Local Name	Underpass	Overpass	Crossing/ Bridge Type
25	54+750	Osborne Store	X		Drainage
26	55+420	Osborne Store	X		Local Road
27	55+660	Toll Gate	X		Field Connector
28	56+055	Toll Gate		X	Interchange
29	56+360	Toll Gate	X		Local Road
30	56+735	Toll Gate	X		Local Road
31	57+720	Clarendon Park	X		Local Road
32	58+336	Clarendon Park	X		Irrigation Canal
33	58+730	Clarendon Park	X		Local Road
34	59+180	St. Toolis	X		Local Road
35	62+200	Underpass	X		Local Road
36	63+300	St. Toolis	X		Field Connector
37	64+090	St. Toolis	X		Field Connector
38	64+830	Porus		X	Local Road
39	65+555	Porus		X	Railway Bridge
40	65+865	Porus	X		Local Road
41	66+310	Porus		X	Local Road

1.2.3 Bridges and Culverts

The bridges and culverts will be designed to meet the requirements for functionality, safety of structures, cost effectiveness, durability of structures, constructability, and aesthetics, thus blending into the surrounding environment to create a harmonious atmosphere.

The structural types of bridges and culverts have been selected by taking into account engineering feasibility, reliability and cost effectiveness to suit the site specific conditions and environment. The following design principles have been adopted to reduce impacts to the surrounding environment while fulfilling the functional requirements:

i. Potential impacts of extreme natural events on the structures

ii. Rational and reasonable layout arrangement of bridge and culvert structures

iii. Minimizing as much as possible the environmental impacts from the construction methods in order to achieve environmental quality objectives;

iv. Comprehensively comparing different structure options in terms of initial capital investment, and long-term operation and maintenance costs in order to minimize the costs while complying with environmental requirements;

v. Creating a durable structure with all the major structural elements being accessible for inspection and maintenance during its service life.

1.2.3.1 Bridge Design Criteria

The bridge design will be in accordance with AASHTO LRFD Bridge Design Specifications, 7th Edition, 2014.

Nº	Item	Required Standard
1	Road grade	Highway-I grade
2	Design speed	110km/h (plain) / 80 km/h (mountain area)
3	Cross slope on bridge floor	2.5%
4	Design life limit	75 years
5	Vehicle load	HL-93

1.2.3.2 Major Bridges

1. ***Rio Minho River Bridge***:

The route crosses Rio Minho River at K44+100. The newly-built Rio Minho River Bridge is located around 100m in the downstream of the old A2 Road Bridge. The stream segment at the bridge location is bent and the route forms a 120° crossing angle with the water flow direction. The bridge span is a 7×30m precast and prestressed concrete T beam, the lower part structure is ribbed plate abutment and column pier, and the foundation is cast-in-situ bored pier.

2. ***Railway Bridge （May Pen - Williamsfield）***

The route crosses the railway at K46+400, and the route forms a 110° crossing angle with the railway. The Railway Bridge is a newly-built bridge. The bridge span is a 4×30m precast and prestressed concrete T beam, the lower part structure is ribbed plate abutment and column pier, and the foundation is cast-in-situ bored pier.

3. ***Overpass Bridge (May Pen - Williamsfield）***

The overbridge crosses the road at K47+400, and the overbridge forms a 90° crossing angle with the road. The bridge span is a 2×30m precast and prestressed concrete T beam, the lower part structure is ribbed plate abutment and column pier, and the foundation is cast-in-situ bored pier.

4. ***Local River Bridge (May Pen - Williamsfield***)

The route crosses the River at K48+550. The reachstream segment at the bridge location is bent and the rout form an 80° crossing angle with the water flow direction. The bridge span is a 2×30m precast and prestressed concrete T beam, the lower part structure is ribbed plate abutment and column pier, and the foundation is cast-in-situ bored pier.

5. *I**nterchange Bridge (May Pen - Williamsfield**)*

The interchange main bridge crosses the road at K56+000, and the overbridge forms an 88° crossing angle with the interchange ramp. The interchange Bridge is a newly-built bridge. The bridge span is a 3×30m precast and prestressed concrete T beam, the lower part structure is ribbed plate abutment and column pier, and the foundation is cast-in-situ bored pier.

1.2.4 Toll Plazas and Equipment

Two toll plazas are proposed, one along the main line in the vicinity of km 70 and km 56 where an interchange is recommended. There are concentrated vehicles and frequent parking and start-up in a toll plaza section, and asphalt concrete pavement easily results in tracking and other pavement damages; therefore, reinforced concrete pavement is used in the design.

Toll plaza pavement structure:

- 26 cm reinforced concrete slab
- 15 cm graded broken stone
- 8 cm caulking crushed stone

1.2.5 Construction Camp/Site Yard and Spoil Sites

There are two (2) camp sites and four (4) spoil sites proposed to support this highway development. Figures 1.3 to 1.6 below illustrate their location along the alignment, which are all on land owned by the Government of Jamaica. Camp site 1 is located within existing cane lands. Camp site 2 is located just west of the Melrose Hill Community.

Spoil site 2 is an existing mined out pit and spoil site 3 will be mined out prior to the construction of the highway and the Jamaica Bauxite Institute is willing to allow for these two sites to be used for this purpose. Spoil sites 1 and 4 are lands currently owned by NROCC.

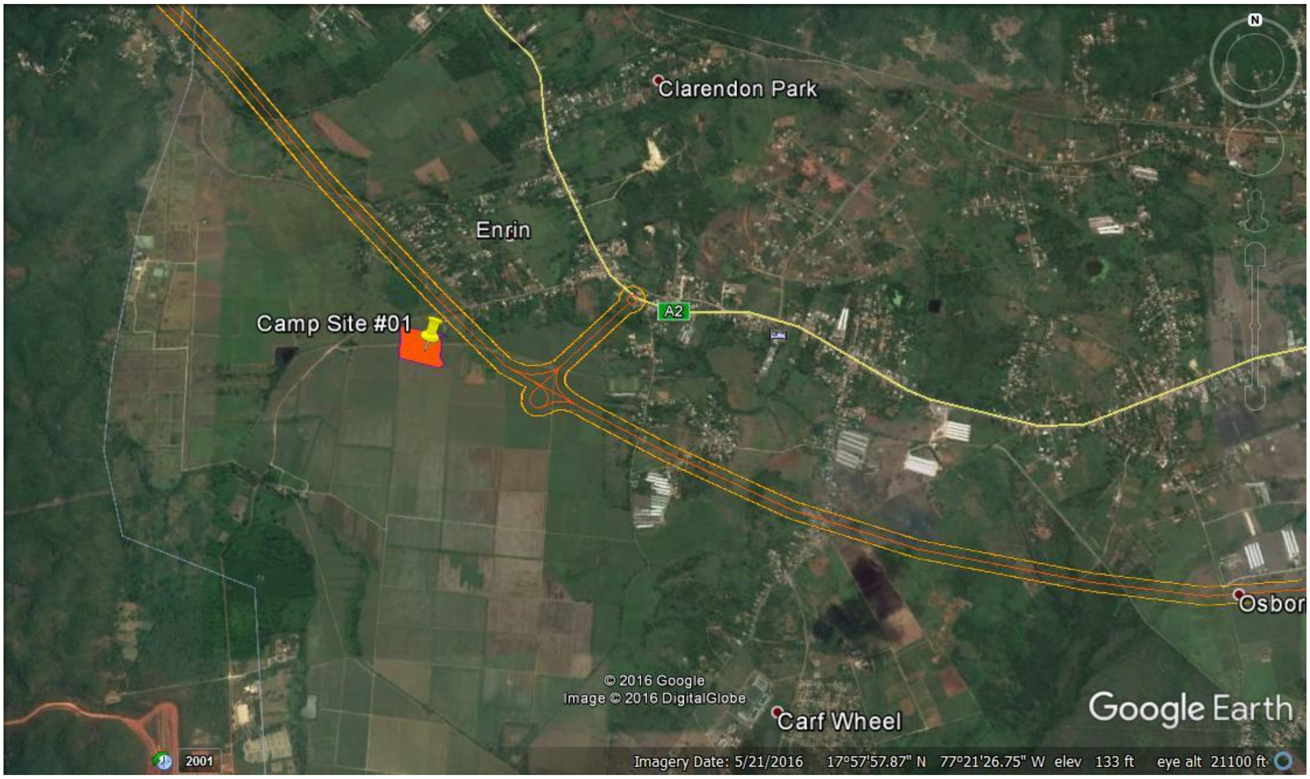


Figure 1.3: Proposed Location of Camp Site 1

Figure 1.4: Proposed Location of Camp Site 2 and Soil Sites 1 and 2

Figure 1.5: Proposed Location for Spoil Site 3

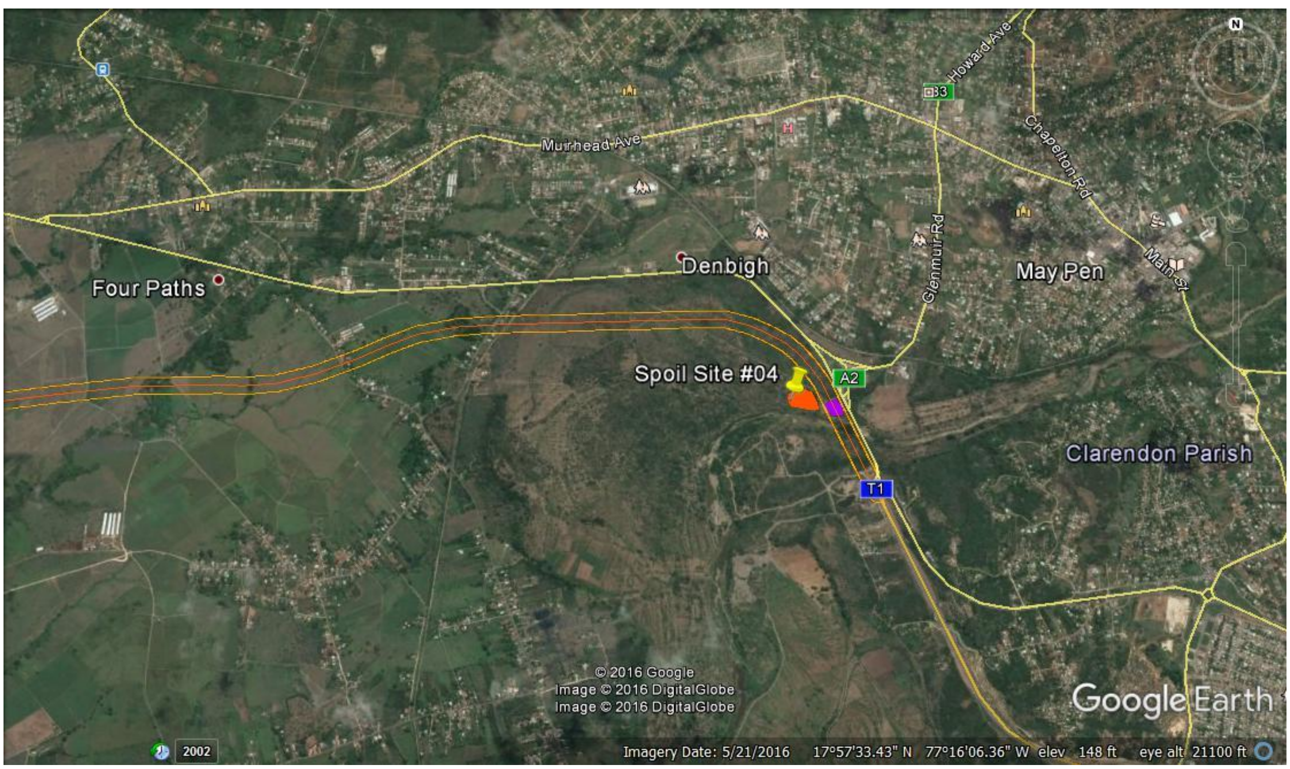


Figure 1.6: Proposed Location for Spoil Site 4

It is anticipated that the camp will be approximately 200m x 200m and will take into consideration requirements for storm water and surface water drainage, location of interceptors, as well as wastewater and sewage disposal. All necessary approvals for the construction camp/site yard will be obtained prior to the establishment of the site. The construction works will be implemented by the contractor.

Although the location of the site construction camp are currently tentative, the previous experience of the Highway 2000 Project should be taken into account, with regards to good housekeeping habits, conformance to permitting requirements, and adherence to audit procedures.

1.2.6 Cut and Fill

It is anticipated that cut and fill will be balanced in that fill materials will be obtained mainly from required cuts and then transported by trucks to the designated fill areas.

Quarries will be identified based on the following criteria:

i. Proximity to project

ii. Type of material required

iii. Nature of approval from authorities.

If the project requires the establishment of a quarry, the necessary licences/approvals will be sought.

1.3 PROJECT PHASING AND TIMETABLE

The project is scheduled to be completed within 36 months after the commencement certificate has been issued. The project will be divided into phases that will be defined by the construction requirements. Details on proposed activities are presented below.

1.3.1 Phases of Construction

1.3.1.1 Pre-Construction Phase

The pre-construction phase for the project is expected to include, but is not limited to, the following:

- **Soil/Geotechnical Investigation:** A requirement for major road structures, particularly for bridges, interchanges and some overpasses, this will involve the drilling of boreholes for field testing and sampling as well as laboratory tests for the soils collected on site. Trial pits and trenching may also be required to assess the sub-grade conditions of the soil on which deep fill will be placed for road construction.

- **Geophysical Surveys:** These will determine seismic wave velocities, particularly in rock mass, to assist in the design of benched slopes and, where necessary, to identify underground cavities in the limestone.

- **Slope Stability Analysis:** This procedure will be critical for embankment slopes as well as excavated slopes.

- **Realignment or re-modification:** This will be carried out on small sections of the highway route where it becomes absolutely necessary to do so.

- **Construction aggregate:** Identification and testing of source aggregate for application as fill and asphaltic mix. Tests will include LA Abrasion, Compaction, Aggregate Crushing Value (ACV), and Specific Gravity tests.

- **Quarry Licence/Development of Quarry:** If suitable material is identified as construction fill, then a quarry licence will be required from the Mines and Geology Division for quarrying the material to be used in highway construction.

- **Selection of Camp/Construction Sites:** Camp sites will be identified near to the highway alignment for the storage and maintenance of heavy duty construction equipment. Additionally, the camp site will be used for the storage of construction material, such as sand and gravel aggregate and bitumen for road construction application as well as for the erection of a concrete batching plant for mixing of cement.

- **Site Preparation**: This will include the excavation of top soil, demolition of structures within the alignment as well as the clearing of vegetation along the highway alignment.

1.3.1.2 Construction Phase

It is anticipated that the entire construction period for the highway will last 36 months. The steps are broken down as per below. It will take 18 months to complete the roadbed construction work and it will follow the procedures outlined below in Figure 1.7.

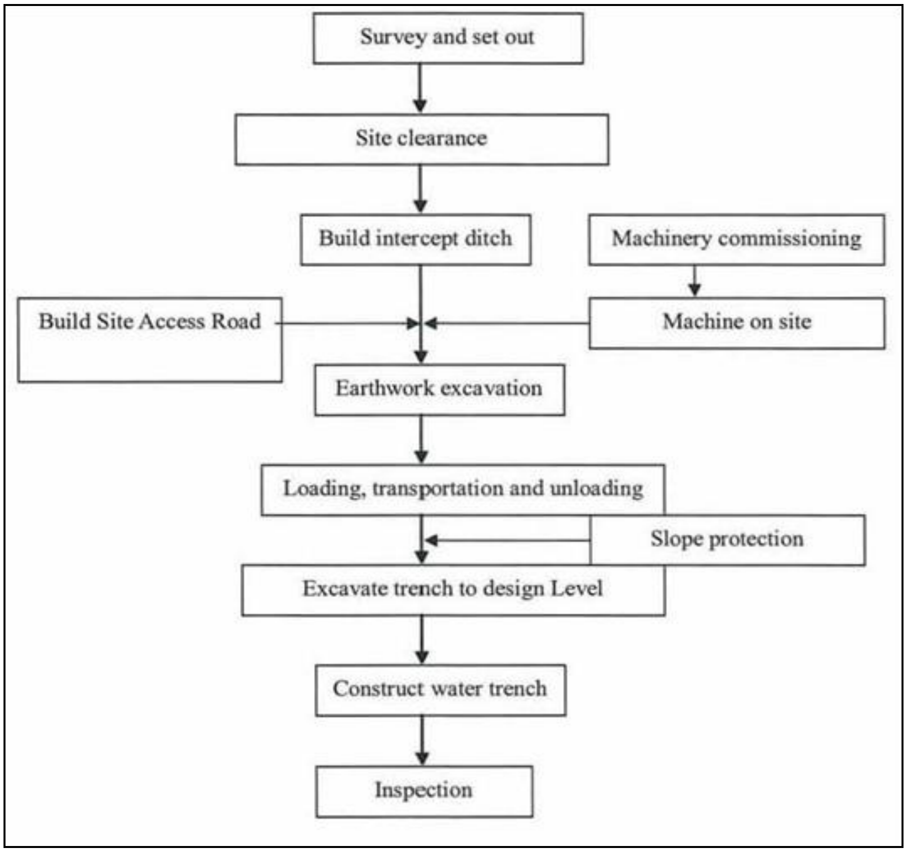


Figure 1.7: Roadbed Construction Procedure

Movement of Equipment on/off Site: Typical equipment for highway construction includes bulldozers, excavators, hydraulic compressors, rollers, compactors, water trucks, haulage trucks, trailers, pavers, and so on. These pieces of equipment will be moving on and off site on a daily basis. A management and operation plan will be in force to ensure efficiency of operations and promote safety to equipment operators. In addition appropriate traffic management will be instituted so as to minimize interruption to the motoring public.

Placement of fill: A major component of the highway construction will be the transportation to, and placement of fill at the construction site, particularly on the May Pen to Clarendon Park leg of the alignment**.** Construction fill up to 11 m thick will be placed, rolled and compacted in accordance with specifications set out by the geotechnical/construction engineer for the project. The fill material will be transported to the construction site from the borrow area and dumped on the site, then spread by bulldozer and trimmed to control the design level. Rollers will then be deployed to compact the material.

Fill work will be started from bottom to top in layer by layer which is shown in Figure 1.8. If uneven ground surface is found, filling and compaction will be applied on the existing ground, and then the layer filled according to requirements. For ensuring the strength and stabilization of road base edge, fill will be placed with 30cm overfill in both sides. The procedure for roadbed filling is shown in Figure 1.9.

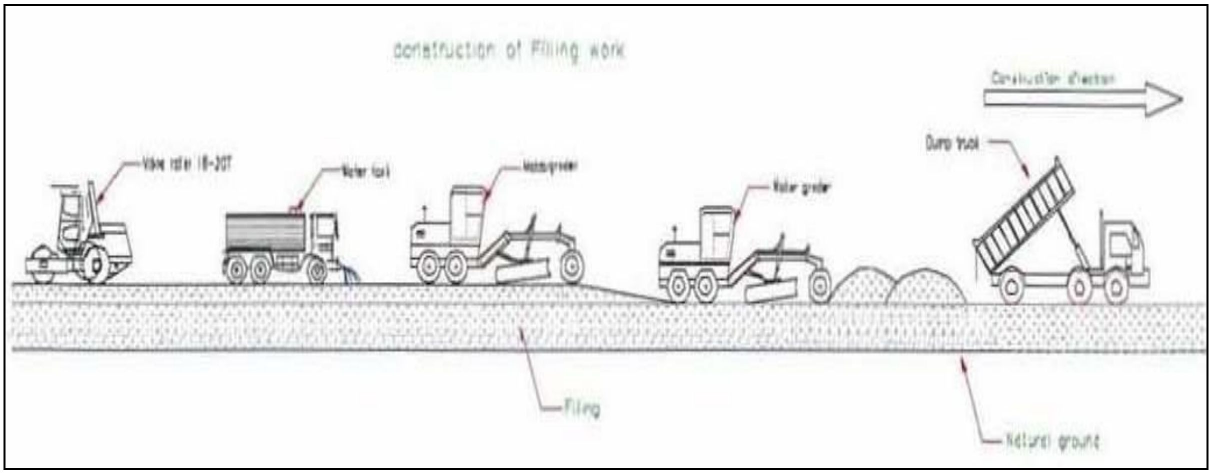


Figure 1.8: The Steps in Transporting, Spreading and Compacting Fill Material

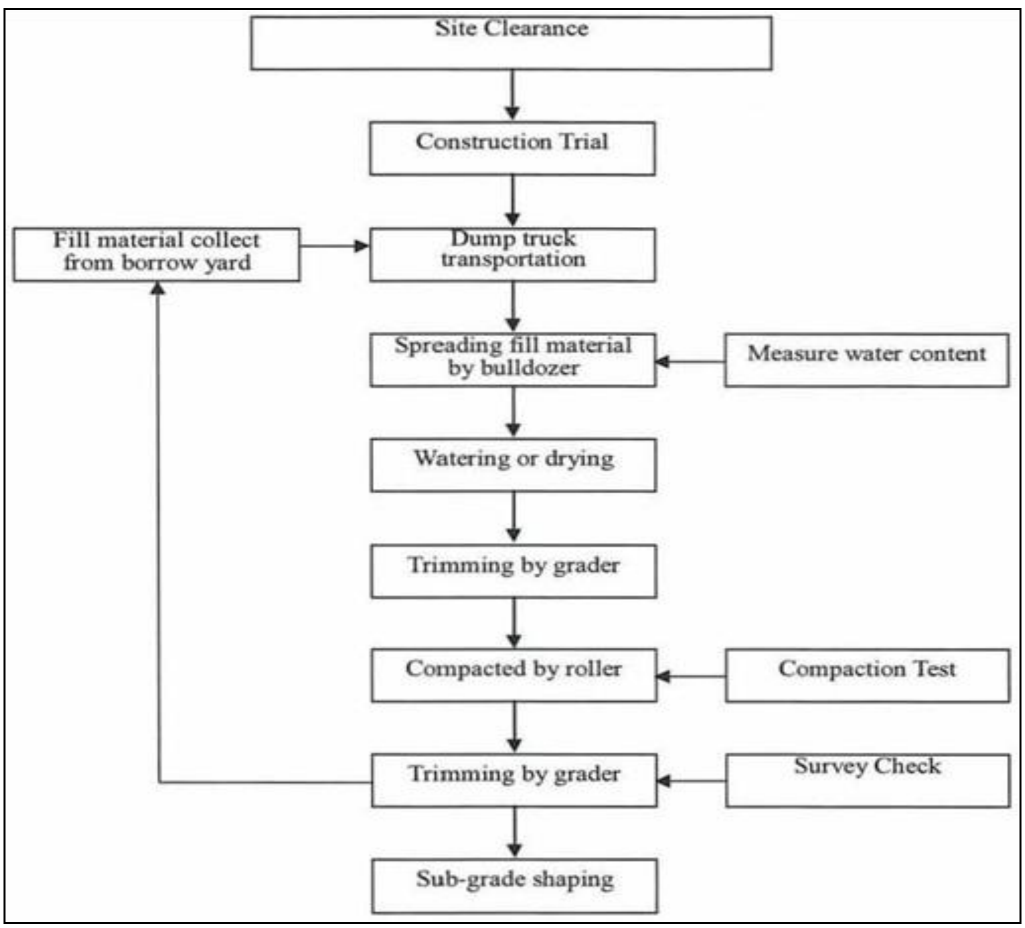


Figure 1.9: Construction Procedure for Roadbed Filling

Earthwork Excavation: Excavation cuts will be conducted in the karst limestone terrain between the communities of Clarendon Park in Clarendon (K59+500) and Williamsfield (K71+770) in Manchester.

Deep cuts up to 27.9m will be excavated in the rock. Excavation of the limestone will be done by blasting and by mechanical excavation where the material is marly and weak. Where weak material is present, bulldozers and excavators with hydraulic hammers will be used to remove the material. However, blast excavation will be the main method for removing material for highway construction. The areas along the route to be excavated are largely unpopulated.

Wetting: Construction fill will be the main material for the construction of the highway. Dust will be a major hazard for communities in close proximity to the highway as well as for construction workers. An important and necessary activity is the constant wetting of the road to minimize dust nuisance during the construction process.

Concrete Ditch: The bedding with crushed stone will be placed after excavation and then concreted to designed level.

Slope Protection Structures: The reinforced concrete retaining wall will be constructed by employing backhoe equipment along with construction workers, such as steel-fixer, carpenter and concreter. Areas with the potential for rock fall hazards will be treated with net mesh and dynamic screens where these are applicable.

Pavement Construction

It will take approximately six months to finish the pavement. One set of 4,000 asphalt batch mixers and three sets of pavers will be deployed to execute the pavement works. The procedure for pavement construction is shown in Figure 1.10.

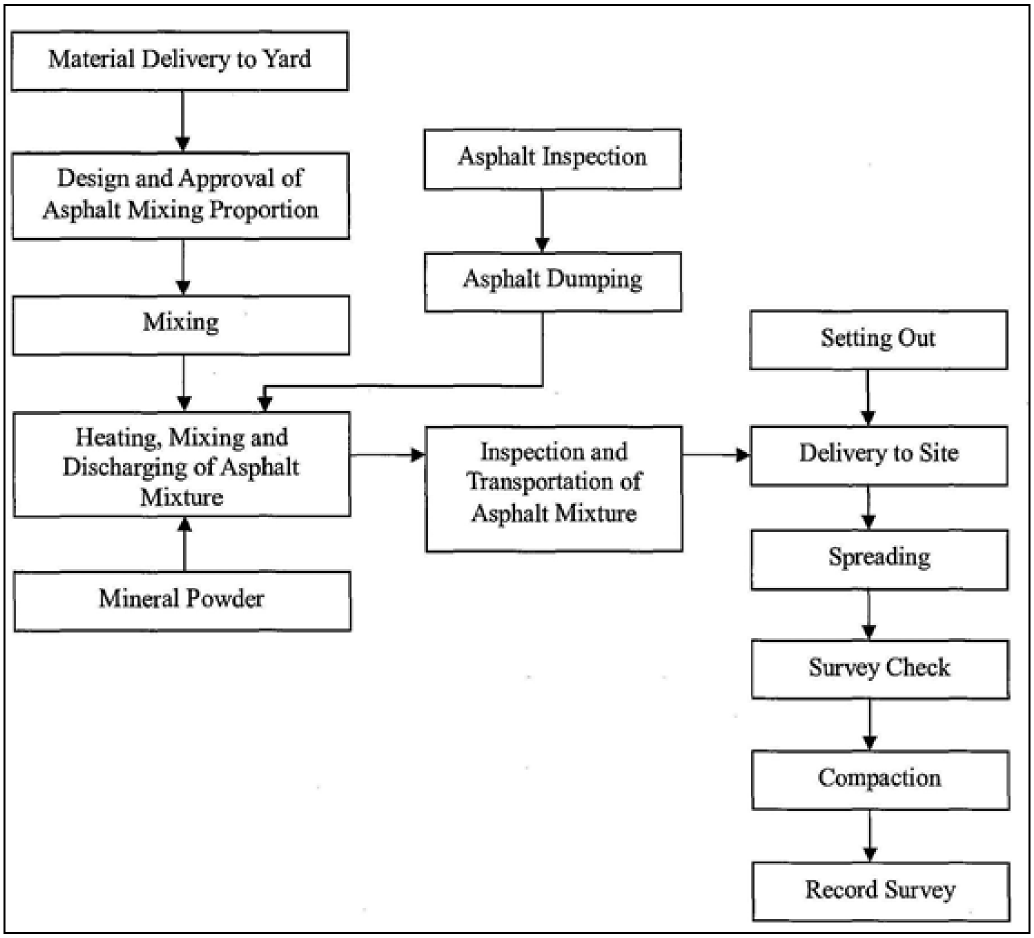


Figure 1.10: Pavement Construction Methodology

Sub-base and Base Course Work: The thickness of base course and sub-base course work is 15cm and 48cm respectively. The graded material will be graded by bulldozer, levelled and spread by a spreader and then compacted to the required degree of compaction.

Prime Coat and Tack Coat Construction: Provide a layer of prime coat or slurry seal on base course and place a layer of tack coat between surface courses.

Figure 1.11: Asphalt Pavement Construction (Spraying)

Asphalt Concrete Pavement: Asphalt concrete shall be transported by dump truck. In order to ensure consecutive spreading work, the dump trucks on site shall not be less than three during the laying of asphalt concrete.

The asphalt concrete will be spread by three ABG-type Pavers equipped with auto-adjusting thickness devices and auto-levelling device and initial-compacting device. The Paver will be adjusted to the best working condition to ensure that the paving surface is even so as to reduce or eliminate segregation. The elevation control method guided by steel wire shall be applied to spreading. The spreading speed will keep up with material supply and compactors to ensure the consecutive and even spreading without interruption as much as possible.

Asphalt concrete will be immediately compacted after spreading. The concrete will be compacted by 10t dual-drum vibration roller immediately after the paving.

Figure 1.12: Transportation of Asphalt Concrete (Source: Mortley, 2015)

Figure 1.13: Spreading and Compacting Asphalt Concrete

Figure 1.14: Spreading of Asphalt Concrete

1.3.1.3 Post Construction Phase

This phase involves the following activities:

- Decommissioning of camp site
- Restoration of quarry site
- Post-construction monitoring.

2 LEGISLATIVE AND REGULATORY REQUIREMENTS

The EIA completed for 2007 provided the relevant details on the legislative and regulatory requirements for consideration. These are listed below and only those relevant policies, legislation and regulations that have been revised or developed since 2007 are presented below.

2.1 National Legislation – Natural Environment

- Natural Resources Conservation Authority Act (1991)
- Environmental Review and Permitting Process (1997)
- Wildlife Protection Act (1945)
- The Endangered Species (Protection, Conservation and Regulation of Trade) Act (2000)
- The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order (1996)
- Water Resources Act (1995)
- Quarries Control Act (1983)
- The Pesticides (Amendment) Act (1996)
- Clean Air Act (1964)
- Air Quality Regulations (2002)
- The Natural Resources Conservation (Portland Bight Protected Area) Regulations (1999)
- Forest Act (1996)

2.1.1 The Natural Resources Conservation (Permits and Licences) (Amendment) Regulations, 2015

These regulations, developed in 2013, requires the application for the grant of a permit to undertake an enterprise, construction or development of a prescribed description or category in a prescribed area as set out in Form 1 in the First Schedule.

NROCC has applied for a permit for the construction of the highway as required by Section 6 of Form 1 in the First Schedule. This Addendum Report and supporting appendices are a part of the regulatory agency's requirements.

Further, NROCC would need to make the necessary applications to support their campsite and may include Environmental Permit Applications for the following:

- ***Worker housing***
- ***Sewage treatment system***
- ***Petroleum storage tanks***
- ***Batching Plant***

2.1.2 The Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013

Jamaica has prepared and enacted regulations governing the quality of the effluent discharged from facilities to public sewers and surface water systems. The regulation requires that the facility meet the outlined trade effluent and sewage quality standards set by the NRCA. The requisite permits and licences are required to be sought to install and operate sewage treatment facilities and wastewater treatment systems.

If the developer is interested in releasing any effluent into the environment a licence for discharge of trade effluent or sewage effluent will be required. Following receipt of a permit, the developer would be required to monitor the effluent quality based on the frequency outlined in the terms and conditions of the licence and submit monitoring reports accordingly.

1.1.1 The Protected Areas System Master Plan (PASMP), 2015

The PASMP covers a five-year period (2013–2017) and presents guidelines to establish and manage a comprehensive network of Protected Areas. The PASMP enables Jamaica to:

1) Relate protected areas to national priorities;
2) Move away from a case-by-case approach to resource management;
3) Make additions to the PA System in a more rational and integrated manner;
4) Facilitate integration with other development plans such as those for tourism, biodiversity conservation, and sustainable development;
5) Implement an improved process for the management of PAs, by sharing resources and responsibilities among government agencies, communities, NGOs, and the private sector;
6) Improve meeting obligations under international treaties.

The Protected Areas System Master Plan (PASMP) aims to develop a comprehensive and representative system of protected areas and a framework for management that supports national development. The PASMP sets out to ensure long-term viability by maintaining ecological processes and systems and protecting the country's natural and cultural heritage. The master plan consists of 13 goals, which were derived from the goals and activities of the CBD's Programme of Work on Protected Areas. Each goal has an action plan that outlines the targets to be achieved and identifies the organization responsible for lead implementation of the associated activities. The PASMP's goals respond to the gaps and challenges that currently exist in protected areas management. In order to support the implementation of the master plan, the government has prepared drafting instructions for an overarching protected areas act. This new act will seek to harmonize the common management aspects for protected areas. This will serve to increase the management effectiveness for all areas.

Phase 1C does not pass through any protected areas.

1.1.2 The Forestry Policy (Green Paper), 2015

This Policy governs all forests in Jamaica whether owned by the State or by private interests. Its scope covers land with reforestation potential and forests in urban settings and addresses national priorities as well as international obligations and commitments relating to climate change, biodiversity conservation, and the sustainable use of wetlands. The goals of this Policy can be classified under three broad headings which relate to:

- Governance of the forestry sector and, more specifically, the mandate of the Agency, other public sector entities and other interest groups in this regard;
- The conservation and protection of forest ecological systems; and
- Relevant socioeconomic considerations.

Following two years (2011–2012) of extensive consultations, a new Draft Forest Policy (2013) was presented and moved to Green Paper status in February 2015. This new policy will provide the basis on which the necessary changes to the legislative and management framework can be instituted. The policy will address crucial gaps and needs for the sector, namely,

- The development of forest management plans,
- The introduction of mechanisms to govern forest management data collection,
- The demarcation of jurisdictional boundaries and the regulation of
    - activities on Crown and privately-owned lands
    - the forest sector and
    - forest-based industries
- Documenting the importance of a wide stakeholder involvement in the management of the island's forests to include the public and private sectors, non-government organizations, community-based organizations, Local Forest Management Committees (LFMCs) and special interest groups.

It is expected that amendments will be made to the Forest Act upon completion of the Forest Policy legislative process.

Phase 1C does not pass through any prime forestry areas.

1.1.3 Management and Recovery Plans for Endangered Species

Management and recovery plans for endangered species have been completed over the last few years. These include the Crocodile Action Plan; the Giant Swallowtail Butterfly Recovery Action Plan; the Jamaican Iguana Conservation Strategy; the Sea Turtle Management Plan; the Jamaica Coral Reef Action Plan; the Development Management Plan for Game Birds; the Development Management Plan for Bats; the Queen Conch Management Plan; and the Plan for Managing the Marine Fisheries of Jamaica. In addition, management plans have been developed for other non-threatened species such as the Sooty Tern and the Brown Noddy. The objectives of these policies and action plans are as follows:

- identify projects and programmes to protect species which are endangered and threatened;
- seek to mitigate adverse impacts on the destruction of habitats across the country;
- aim at changing behaviour and educating the public on aspects of biodiversity; and
- recommend increased means of protection under the law for our natural resources and the environment.

Endangered species have been identified in the biological assessment and as such mitigation measures to reduce the impact on these species will need to be taken into consideration.

2.2 National Legislation – Socioeconomic Environment

National Legislation – Socioeconomic Environment
• *Town and Country Planning Act (1958)* • *Land Development and Utilization Act (1966)* • *Public Health Act (1976)* • *Country Fires Act (1942)* • *The National Solid Waste Management Authority Act (2001)* • *Jamaica National Heritage Trust Act (1985)* • *Land Acquisition Act (1947)* • *Registration of Titles Act (1989)* • *The Mining Act Regulations (1947)* • *The Main Roads Act (1932)* • *The Toll Roads Act (2002)*

2.2.1 The Quarry Control (Amendment) Act (2015)

The Quarries Control Act was amended in 2015. The Act provides for the establishment of a Quarries Advisory Committee (Section 6) to designate quarrying zones and to license operators. It makes provisions for written notice to be served on persons operating quarries if the operation is detrimental to the fauna and flora of the neighbourhood (Section 29). Where illegal quarrying activities exist, the Court may order that any fine imposed under the Act be directed towards the rehabilitation of the illegally operated quarry.

Any quarries used to provide material for the project should be licensed by the Mines and Geology Division and NEPA.

2.3 International Legislative and Regulatory Considerations

2.3.1 Convention on Biological Diversity

The Convention on Biological Diversity creates the framework for Parties to implement national legislative, policy and administrative measures. The Government of Jamaica plans to fully implement the provisions of this Convention by carrying out the necessary legislative changes required to fulfil the country's obligations.

2.3.2 Cartagena Convention (Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region) (1983)

Adopted in March 1983 in Cartagena, Colombia, the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, also known as the Cartagena Convention, is a legally binding environmental treaty for the Wider Caribbean. The Convention came into force in October 1996 as a legal instrument for the implementation of the Caribbean Action Plan and represents a commitment by the participating governments to protect, develop and manage their common waters individually and jointly.

The Convention is currently supported by three Protocols. These are:

- *The Protocol Concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region* (The Oil Spills Protocol), which was adopted and entered into force at the same time as the Cartagena Convention;
- *The Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean Region* (The SPAW Protocol), which was adopted in two stages, the text in January, 1990 and its Annexes in June, 1991. The Protocol entered into force in 2000;
- *The Protocol Concerning Pollution from Land-based Sources and Activities in the Wider Caribbean Region* (LBS Protocol), which was adopted in October, 1999.

2.3.2.1 National Biodiversity Strategy and Action Plan 2016

This document was completed in 2016 and speaks to the Jamaica's continued commitment to its obligations as a signatory to the Convention on Biological Diversity.

In meeting the Convention and Protocols, NROCC would be committed to following all of their supporting local environmental regulations and legislation.

3 METHODOLOGY AND APPROACH

3.1 GENERAL APPROACH

The Consultants conducted the studies for the EIA Amendment based on the Terms of Reference (TOR) received from the Client, and which represented the agreed TOR between the NEPA and NROCC. Appendix I elaborates.

A multidisciplinary team of experienced scientists and environmental professionals was assembled to conduct the required resource assessment, generation and analysis of baseline data, determination of potential impacts and recommendations for mitigation measures. An iterative approach among the environmental team members and other project professionals was adopted, and was facilitated by fortnightly team meetings as required. This also included meetings that were held with the client and the project team.

The team utilized the Charette-style approach to data gathering, analysis, and presentation, whereby team members conducted the reconnaissance investigations together to determine critical elements for analysis and the issues to be highlighted for the design and planning process. Team meetings were used as a means to discuss the progress of investigations and analyses and to 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 were generated using a combination of research approaches:

- Field investigations
- Analysis of maps, plans, aerial photos
- Review of reports and background documents
- Structured interviews
- Laboratory analyses.

3.2 PHYSICAL ENVIRONMENT

3.2.1 Climate and Rainfall

Data for Jamaica and the two key parishes, Clarendon and Manchester, were compiled to present an overview of the typical climate in the project area.

3.2.2 Site and Situation

The location of the proposed alignment relative to geographic indices, existing developments and major transportation arteries was determined in order to identify the site and situational context. This was done using maps, plans, photos and site reconnaissance.

3.2.3 Air Quality

Particulate matter is the term given to small solid or liquid particles suspended in either a gas or liquid. The size of these suspended particles not only determines the lifespan of the particles within the atmosphere, but also their fate if respired. The size range of concern to human health lies between 0.1-10 µm, and is referred to as respirable particulates. Effects of the exposure of PM10 on human health include, but are not limited to, effects on the respiratory systems, damage to lung tissue, the development of cancerous tumors, and premature death. The age, gender and health of the individual will determine the extent of these effects.

To minimize the potential impact of particulate matter on the health of people and the environment, the United States Environmental Protection Agency has published the national air quality standard which states that the maximum daily concentration should not exceed 150 µg/m^3. A similar 24 hour ambient standard is adapted by the local regulatory agency, the National Environment and Planning Agency (NEPA).

Particulates were measured using calibrated SKC pumps (with flow rates 1-5 and 5-15 L/min), attached to pre-weighed SKC Polyvinyl Chloride (PVC) filters. The pumps were calibrated with a factory calibrated DryCal DC-Lite primary flow meter from Bios International Corporation. The pumps were calibrated prior to their use and their flow rates checked again after the sampling session to ensure they operate within the calibrated flow rate. In the field, the pumps will be placed at the approximate respiratory height of the individual/s for a 24-hour period for a total of three consecutive days, accumulating to produce a reading for 72 hours. The pumps were then returned to the ESL laboratory where the filters were stabilized and weighed to determine a Time Weighted Average (TWA) value for the particulates.

The results at the end of the sampling period were compared with the standards of the National Environment and Planning Agency (NEPA) and the Occupational Safety and Health Administration (OSHA).

Site Selection

The objective of the air quality baseline investigation was to determine the normal concentration of respirable particulates in the project area. The selection of the sampling points was done primarily based on the proximity of the proposed alignment to human receptors and environmentally sensitive areas. Receptor sites located downwind of the project sphere which may be affected by the activities on the project site were selected. Air quality measurements were taken at eight sites in the project area. The air monitors were placed away from any known sources to prevent bias in the data collected. Each sampling station was geo-referenced for traceability and future monitoring requirements.

The sites are described in Table 3.1 and illustrated in Figure 3.1 below.

Table 3.1: Air Quality and Noise Sampling Stations

Sample ID	Sample Location	Type of Assessment	Description
York Town Road Four Paths (AQ 1) Noise (Station 1)	N 17.961997° W0 77.277813°	Air & Noise	The monitor was placed approximately 20 metres away from the main thoroughfare. Traffic was moderate to heavy in both

Sample ID	Sample Location	Type of Assessment	Description
			directions. The sampling location was a vegetative area with large fruit and non- fruit trees and shrubs. At the time of the investigation, the sky was clear and sunny with moderate to light winds blowing from the east in a westerly direction.
Denbigh Drive (AQ 2) Noise (Station 2)	N 17.960079° W0 77.285830°	Air & Noise	The air monitor was placed on a grass plain on a shrub approximately 10 meters away from the main road. Traffic along the road was light. The plain was bordered by canefields to the east and large trees to the south. The sky was sunny with light winds from the east moving in a westerly direction.
Decoy at Toll Gate (AQ 3) Noise (Station 3)	N 17.959890° W0 77.348920°	Air & Noise	The air monitor was placed on the eave of one of the buildings on the Assemblies of the First Born Church. The monitor was placed approximately 10 meters away from the main road. Traffic was light along the main road. The sky was sunny with light winds from the east moving in a westerly direction.
Duke Street (AQ 4) Noise (Station 4)	N 17.962640° W0 77.355560°	Air & Noise	The air monitor was placed on a dead tree located on a residential lot which was across from an open grassed plot of land. An unpaved road was located approximately 3 metres from the resident's home. No traffic was observed during the assessment. Meteorological conditions were sunny skies with light to moderate winds moving in a westerly direction.
St. Jago Road - Community Centre (AQ 5) Noise (Station 5)	N 17.969801° W0 77.368904°	Air & Noise	This monitor was placed on the western fence of the community centre. The community centre is located approximately 1 metre away from the main thoroughfare. Meteorological conditions were sunny with partly cloudy skies with light to moderate winds moving in a westerly direction.
Redberry (AQ 6) Noise (Station 6)	N 18.023709° W0 77.419860°	Air & Noise	This monitor was placed under the eave of a house. The house was located approximately 3 metres away from the main thoroughfare which had light traffic during the assessment. The yard around the house was paved and there was primarily thick vegetation in the surrounding environment. Meteorological

Sample ID	Sample Location	Type of Assessment	Description
			conditions were sunny with partly cloudy skies and light winds moving in a westerly direction.
Trinity (AQ 7) Noise (Station 7)	N 18.033583° W0 77.431682°	Air & Noise	The air monitor was placed on an unfinished building located across from an open, primarily grassy area with a few mature trees. The yard around the building was primarily compacted red dirt. A grassy path led up to the sampling station. Background noise included livestock animals. Meteorological conditions during the assessment were sunny and partly cloudy skies and moderate winds moving in a northerly direction.
Hope Village (AQ 8)	N 18.068559° W0 77.460934°	Air	The air monitor was placed along the eastern section of a resident's fence. The monitor was approximately 300 metres away from the highway. Meteorological conditions were sunny with partly cloudy skies and moderate winds moving in an easterly direction.

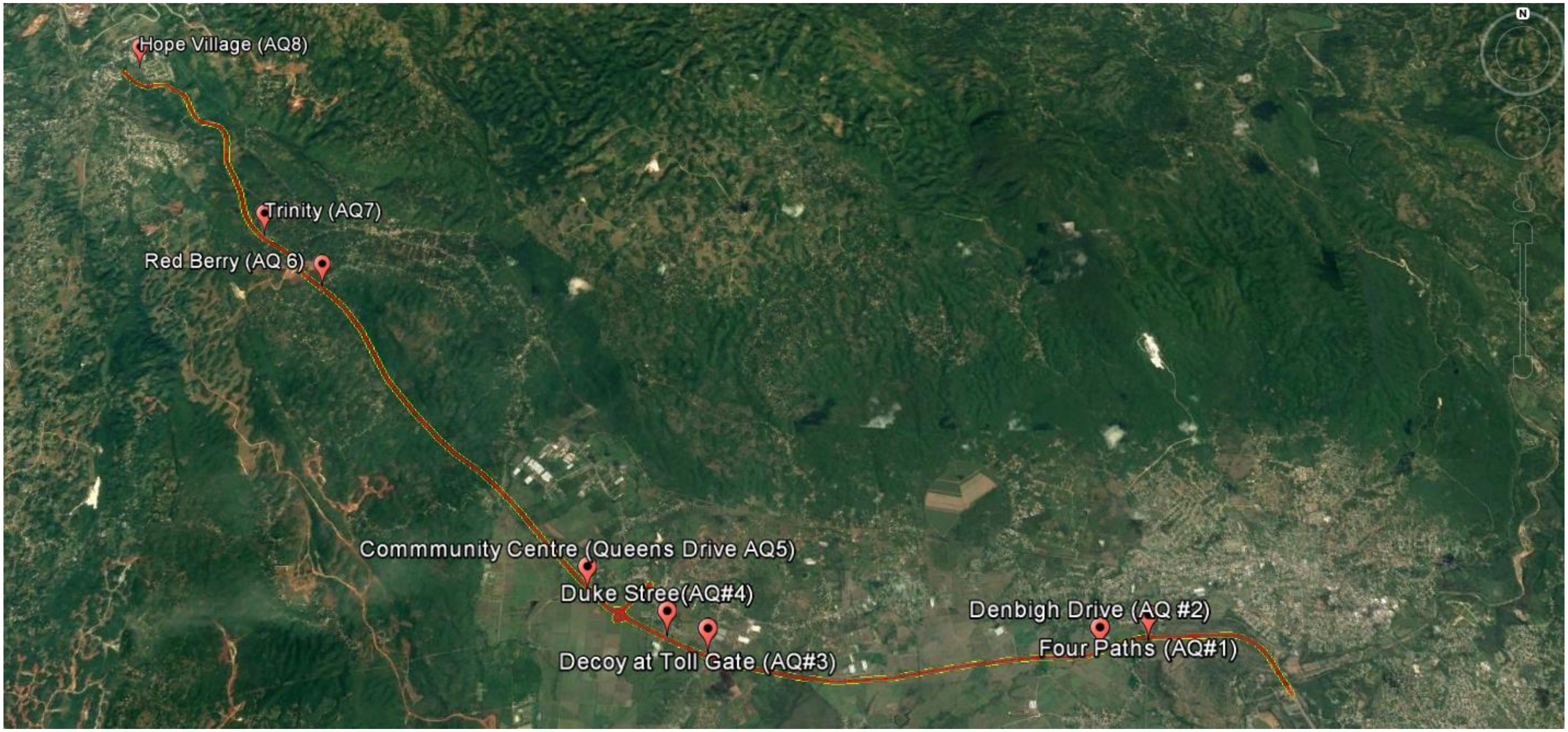


Figure 3.1: Air Quality and Noise Sampling Stations

3.2.4 Noise

The noise assessment was conducted from Wednesday December 28th, 2016 at 7:00am to Saturday December 31st, 2016 at 7:00am. It was conducted along the proposed highway alignment from Four Paths to Williamsfield, Clarendon.

A total of seven (7) stations were monitored over a seventy-two hour (72-hour) period.

The descriptions and GPS coordinates of these noise stations are the same presented in Table 3.1 above.

Noise Level Readings and Octave Band Analysis

Noise level readings were taken using Quest Technologies SoundPro DL Type 1 handheld sound level meters with real time frequency analyzer setup in an outdoor monitoring kit. The octave band analysis was conducted concurrently with the noise level measurements. Measurements were taken in the third octave which provided thirty-three (33) octave bands from 12.5 Hz to 20 kHz (low, medium and high frequency bands).

The noise meters were calibrated for pre- and post-construction noise assessment by using a Quest QC – 10 sound calibrator (Appendix III). The meters were programmed using the Quest Suite Professional II (QSP II) software to collect third octave, average sound level (Leq) over the period, Lmin (the lowest level measured during the assessment) and Lmax (the highest level measured during the assessment) every ten seconds.

Average noise levels over the period were calculated within the QSP II software using the following formula:

$$\text{Average dBA} = 20 \log 1/N \sum_{j=1}^{N} 10^{(L_j/20)}$$

where N = number of measurements, L_j = the jth sound level and j = 1, 2, 3 .... N.

The times on the noise meters were synchronized with the times at the Vineyards Toll Booth so that some correlation with the times and noise levels on the meters could have been made.

Seven (7) noise meters with outdoor monitoring kits (Figure 3.2) were set up, one each at each location listed in Table 4.2. These meters were left for the entire seventy-two (72) hour assessment period in an outdoor measuring system and programmed to collect data every 10 seconds.

A windscreen (sponge) was placed over the microphone to prevent measurement errors due to noise caused by wind blowing across the microphone. The microphone of the meters were at a height of approximately 1.5m above ground and had an unobstructed view of the roadway (>135°). There were no vertical reflecting surfaces within 3m (10 feet) of the microphone.

Noise statistics (L_{10} and L_{90}) will also be calculated at each location.

Figure 3.2: Photograph showing Example of Noise Meter Setup

3.2.5 Water Quality

Water samples were collected from four (4) locations (two (2) upstream from the project area and two (2) downstream) within and in the vicinity of the project area to determine the baseline quality of the major surface water systems which traverse the alignment of the highway. The baseline water quality assessment had the following major objectives:

- To assess land use practices prior to the construction of the proposed highway by determining their impacts on the existing surface water system;
- To establish baseline water quality conditions of the surface water systems that traversed by the proposed alignment.

Water samples were not collected from both the Rio Minho and Milk Rivers during this sampling exercise for the following reasons:

- Rio Minho

  During the sampling exercise water was not flowing in the Rio Minho, small stagnant pools of water were, however, observed along the river bed.

- Milk River

The river upstream of the proposed path of the highway was dry. It was noted that the National Irritation Pumping Station was active and water was observed being pumped into the irrigation canals near to the proposed sampling site. The river downstream the projected path of the highway was also dry.

Despite the current conditions of the both rivers, these sampling sites should be monitored when possible to determine whether or not the system will be impacted especially by sediment runoff from the highways' construction. Elevated sediment levels within water systems will increase the mortally rate of aquatic animals and plants by:

- Decreasing the oxygen content of the water,
- Affecting photosynthesis process within aquatic plants due to poor sunlight penetration,
- Increasing the temperature of the water, and
- Increasing the levels of heavy metals and other contamination within the water column.

The monitoring of the existing Gullies which traverse the proposed path of the highway is necessary to determine what effects (if any) the construction of the highway will have on these systems. It should be noted that both these gullies eventually empties into the Milk River. The water in the gullies may also be used for irrigation purposes.

The samples were collected below the surface of the water to an appropriate depth depending on the depth of the water column at the time of sampling. Depending on the parameters being tested for, some of the sample containers were rinsed thrice with the water to be sampled before the actual sample was collected. The samples were collected where the water is well mixed, far enough from points of significant inflows.

Each sample was collected directly into pre-cleaned and pre-labeled polyethylene or glass bottles (depending on the analysis). Bacterial samples were collected in sterilized 100 – 250ml bottles or bags. After collection, the samples were immediately stored on ice and analyzed within the respective parameter holding time. The analytical methods are presented in Appendix II.

The water samples were analyzed for the following biological parameters:

- Biological Oxygen Demand
- Chemical Oxygen Demand
- Turbidity
- Total Suspended Solids
- Nitrate
- Phosphate
- Sulphate

- Chloride
- Total Coliform
- Faecal Coliform
- Alkalinity
- Hardness
- Silica
- Potassium
- Lead
- Mercury
- Arsenic
- Total Petroleum Hydrocarbons
- Polycyclic Aromatic Hydrocarbons
- Fats Oil and Grease

Field observations and *in situ* measurements were made with respect to pH, dissolved oxygen, electrical conductivity, salinity, dissolved oxygen and temperature at each site using a calibrated YSI MPS Model 556.

All point and potential non-point sources of contamination to surface waters were identified. Each sampling station was geo-referenced for traceability and future monitoring requirements. The locations of the sampling stations are presented in the Table below.

Table 3.2: Name and Location of Water Sampling Stations

Sample ID	Sample Location	Water Type	Description
St. Anne's Gully Downstream (SP 1)	N 17.956922˚ W077.296968˚	Surface Water	Sampling was done from a canal and the sampling site is located south of a small bridge. Samples were taken at a depth of approximately 0.5 metres below the water surface. The water sample was clear with pale green in colour. The flow of the water in the canal was slow. Plastic bottles and other debris were being collected just under the bridge. Duckweed also colonized the water at this location. The canal north of the bridge was overgrown with grass. Small aquatic animals such as fish and tadpoles were observed in the water column. Background noise included the rustling of leaves in the wind, the chirping birds and the sounds of insects. Meteorological conditions were sunny with slightly cloudy skies and moderate winds moving in a westerly direction.
St. Anne's Gully Upstream (SP#2)	N 17.964221˚ W077.288095˚		Sampling was done from a canal and the sampling site is located just after a weir under a bridge. Samples were taken at a depth of approximately 0.25 metres below the water surface. The water

Sample ID	Sample Location	Water Type	Description
			sample was clear and colourless. The flow of the water in the canal was slow and in a southern direction. Plastic bottles, styrofoam boxes and other debris were being collected just under the bridge. Aquatic animals such as fish and snails were observed in the water column. Several electrical wires were observed in and above the canal. Background noise included the rustling of leaves in the wind, the chirping birds and the sounds insects. Meteorological conditions were sunny with slightly cloudy skies and moderate winds moving in a westerly direction.
Duke Street Upstream	N 17.969092˚ W077.357596˚		Samples were taken from the St. Anne's Gully and the sampling site is located at a bridge. Samples were taken at a depth of approximately 0.5 metres below the water surface. The water sample was clear and a pale green colour. The flow of the water in the gully was slow and was moving in a southern direction. Plastic bottles and other debris were being collected just under the bridge. Aquatic animals such as fish and turtles were observed in the water column. Background noise included the rustling of leaves in the wind, chirping birds, the sounds of insects and the noise of vehicular traffic. Meteorological conditions were partly cloudy skies and moderate light winds moving in a southerly direction.
Duke Street Downstream	N 17.957104˚ W077.357761˚		Sampling was done from a canal and the sampling site is located near a bridge. The canal was overgrown with grass and aquatic plants. Samples were taken at a depth of approximately 0.5 metres below the water surface. The water sample was clear and had little suspended solid. The flow of the water in the canal was slow and was moving in a westerly direction. Aquatic animals such as fish and snails were observed in the water column. A chicken coop was located to the east of the canal with canefields to the north and south. Background noise included the rustling of leaves in the wind, the chirping of birds and the sounds of insects. Meteorological conditions were sunny with slightly cloudy skies and moderate winds moving in a northerly direction.

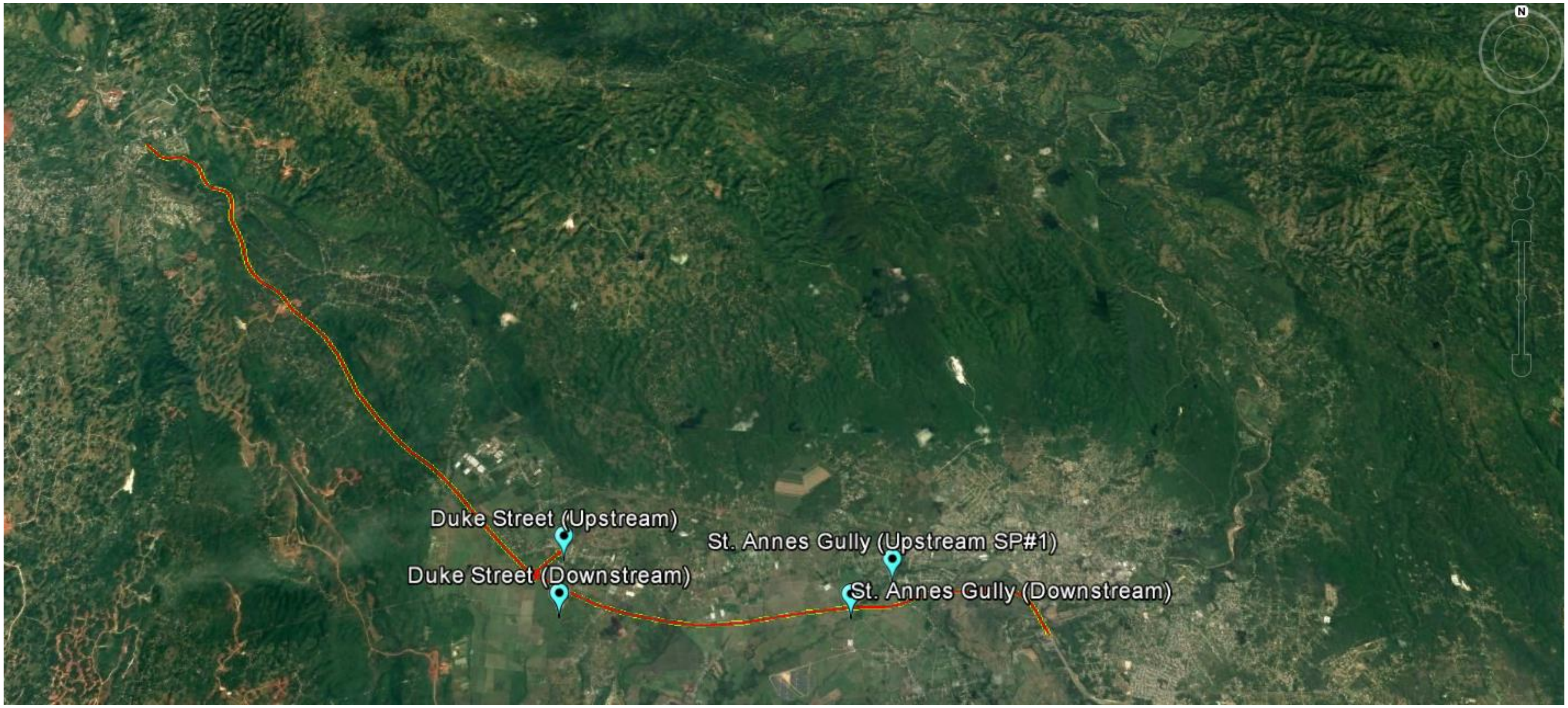


Figure 3.3: Water Quality Sampling Stations

3.2.6 Topography, Geology and Soils

Field visits were conducted along the highway alignment. The Consultants used 1:12,500 imperial topographic maps (sheets 65A, 65C, 65D, 66B, and 76A) to identify in detail topographic and geomorphic features and patterns on the highway alignment as well as to assist with field work. Aerial photographic interpretation using black and white panchromatic photographs (1953–54 series) for the project at a scale of 1:12,000 -1:15,000 was also helpful. A desk study review was conducted. Sweeting's (1958) classification for karst geomorphology was also adopted for the analysis.

For the soil analysis, the Agricultural Soil Classification of Jamaica developed by the Rural Physical Planning Unit of the Ministry of Agriculture and the Engineering Classification of Jamaican Rocks and Soils by the Geological Survey Division were utilized.

Geological field work was conducted to identify and describe the rock types and confirm the presence of fault zones within the project area. In addition, 1:50,000 Provisional Geology Maps (Sheets 16 and 17) and 1:50,000 Imperial Geology Map (Mandeville Geology Sheet 13) which cover the project site were used to assist with geological interpretation. Other secondary research was undertaken through review of relevant documents.

3.2.7 Hydrology, Drainage and Flooding

Historical data on surface and ground water regimes were investigated, including the following:

- Drainage and Hydrology Report – Volume 1 (2000)
- Drainage and Hydrology Report – Volume 2 (2000)
- Geotechnical Study Report (2000)
- Highway 2000: Phase 1B Sandy Bay to Williamsfield Km: 33+000 to 71+500 Environmental Impact Assessment (EIA) Report (2007)
- Flood Risk Management Along Highway 2000 Corridor Report (2012)
- Flood Risk Reduction Along Highway 2000 Appendices (2012)

Aerial photographs were also examined to determine the nature and extent of frequent flooding events. Field studies were conducted to determine the present conditions and flows in these water courses with special attention being paid to breaching and overtopping areas. Anecdotal reports were obtained to determine the extent of the most recent flooding events.

Different approaches were used to determine the expected flows based on the size of the catchment. For the larger catchments (>25km^2) computer simulations using HEC-HMS were compared to the Highway 2000 Project Drainage and Hydrology Report Volume I and II and reported in Table 4.10 for locations along the Rio Minho, St. Anne's Gully and Milk River. The 1986 peak flows were also reported to provide a comprehensive envelope for the type of peak flows that have been measured or evaluated.

For smaller sub-catchments, the Flood Risk Management along Highway 2000 Corridor (2012) report by Stanley was utilized.

For runoff from the highway, the Rational Equation was used to assess contributions from 100m segments of the highway post-development that may be directed to the existing major crossings. 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 m3/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 any 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 of water 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.

Rainfall values from the Stanley (2012) report for 24-hour rainfall depths for Belle Plain/Osborne Store as outlined in Table 3.3 below were used.

Table 3.3: Design 24 Hour Rainfall Depths (mm)

Area	10yr Return	25yr Return	50yr Return	100yr Return
Belle Plain/Osborne Store	275	360	432	512

3.2.8 Natural Hazard Risk

Assessment of natural hazard risks (flooding, hurricanes, seismicity, climate change and extreme weather events) was done through a review of relevant literature pertaining to climate, soils, geology and drainage; site assessment to identify landslides; and anecdotal reports on historical events from residents in the surrounding communities. Other issues such as groundwater pollution incidents were reviewed within a 5 km radius of the alignment. Aerial photographic interpretation and literature review were also conducted.

3.3 BIOLOGICAL ENVIRONMENT

The section of the alignment between the May Pen Bridge and Clarendon Park passes through the Vere Plains which are typically less than 200 feet above sea level and consists of the alluvial flood plains of the Rio Minho and Milk Rivers. The area has long been cultivated primarily with Sugar Cane and includes pastures. The area remains in mixed cultivation and is highly disturbed.

The western sections of the alignment passes over limestone hills which have a more varied land use with disturbed limestone forest mixed with small plots of cultivated and fruited pockets of land as well as bauxite mining. The steepest portions of the limestone forests are the least disturbed probably because they are the least suited for cultivation. However, site assessments suggested that the demand for land in the area appears to be very high as there are areas with very small pockets of soil in the limestone rocks and these areas are being planted and farmed. Elevation of this area ranges from approximately 200ft to 900ft in sections.

Wildlife abundances were relatively low in much of the study area, which is expected given the high levels of long term disturbance and land use changes caused by human activity. Birds were numerous within the area, but the species encountered were common, widespread and typical of disturbed habitats.

The reconnaissance site visit was conducted on November 17, 2016 and following that, a biological environment assessment was conducted in terms of flora and fauna, identification of any rare, threatened or endangered species, existing habitats, and sensitive ecosystems. These sub-tasks include:

(i) Assessment of the state of existing vegetation, invertebrates, bird population;
(ii) Determination of potential biological impacts during the construction and operational phase as a result of the proposed development;
(iii) Analysis of the project's potential to destroy, alter, or lose natural biological features, habitats and species previously identified in ecological surveys.

Details of the floral and faunal assessment are explained in Section 4.4 below.

3.3.1 Existing flora and fauna

3.3.1.1 Plants

Plant communities were assessed using Google Earth images and the results used to stratify sampling. Comprehensive lists of plants in all of the main habitat types were developed based on field surveys on December 14 and 17 2016. Unknown plants were photographed or collected and identified at the University of the West Indies Herbarium. Plants were classified into abundance classes using a **DAFOR**[3] scale based on observations within the habitat type. A species-area curve was used to determine the adequacy of the number of sample points.

3.3.1.2 Birds

Bird sampling took place during December 2016 and January 2017. Relevant data that were collected in June-July 2007 as a part to the assessment of the old alignment were also included in the assessment and analysis. Point counts were carried out at 13 points in December 2016 and these data was combined with the 13 points surveyed in August 2007. All point counts were done between 6:30 and 10:00 am. The point count sites were stratified by habitat type and were distributed randomly along the length of the route (Table 3.4 below). Points were also chosen that were as close to the alignment as possible in order to be representative of the habitat of the alignment. Point counts were six minutes long. The number of species and individuals of all species were recorded. The methodology followed recommendations contained in (Wunderle *et al.*1994*)* for sampling birds in the Caribbean. Special night-time surveys using playback were conducted along the route to assess the occurrence of Jamaican Owl and Northern Potoo, ten minutes were spent at each point.

[3] Dominant, Abundant, Frequent, Occasional or Rare,

Table 3.4: Coordinates for Point Counts for new alignment

No.	Wpt No.	Latitude	Longitude
1	47	N 18° 02' 14.2"	W 77° 25' 43.1"
2	Trinity rd	N 18° 01' 56.2"	W 77° 25' 50.2"
3	Redberry rd	N 18° 01' 25.6"	W 77° 25' 11.4"
4	46	N 18° 00' 39.2"	W 77° 25' 01.0"
5	45	N 18° 00' 39.4"	W 77° 24' 37.5"
6	44	N 18° 00' 19.5"	W 77° 24' 28.5"
7	43	N 18° 59' 33.1"	W 77° 24' 33.1"
8	42	N 17° 58' 52.2"	W 77° 24' 34.0"
9	40	N 17° 58' 58.0"	W 77° 23' 59.3"
10	41	N 17° 58' 45.9"	W 77° 24' 05.9"

3.3.1.3 Other fauna

Observations and notes were made for any other fauna encountered in the study area. Local persons encountered during the visits were interviewed to gather additional background information about the presence or absence of other fauna and flora including butterflies, amphibians and reptiles. Some frogs were identified by call during the nocturnal surveys.

3.4 SOCIOECONOMIC ENVIRONMENT

Information on land use, employment and livelihoods, economic enterprise, demography, social/community structures, and traffic and transportation was collected from secondary sources and field investigations.

Field investigations involved a community rapid appraisal and in-depth interviews with key informants and community members in the communities mentioned below.

The methodological approach for the baseline data involved the following methodological approaches:

a. Desk Research
b. Rapid Appraisal

i. Rapid Appraisal
ii. Key Stakeholder Interviews

c. Assessment

3.4.1 Desktop Research

The desk research reviewed and analyzed all the relevant socioeconomic data available from both recommended sources and other national sources that would help to put the project into its local and national context.

Project specific documentation was included in the desktop research, for example, the 2007 EIA for the East West corridor, May Pen to Williamsfield and the Corridor Development Plan. Specifically, much use was made of the Design for Approval documents provided by NROCC.

3.4.2 Rapid Appraisal

The rapid appraisal involved the following established techniques in order to get a quick, but in-depth orientation to the project area and its constituent communities, and to identify key issues for the project to consider:

a) Rapid Appraisal, including reconnaissance;

b) Key stakeholder interviews.

i. Rapid Appraisal

The appraisal began with the reconnaissance, where the study team drove through the project area to familiarize themselves with the locations and landmarks. The opportunity was taken at the same time to determine the key persons who might be strategic in relation to the socioeconomic assessment and to note any features, establishments or activities that might warrant further investigation, such as, heritage elements, social capital, informal or unplanned settlements (including squatting), obvious forms of environmental degradation, other related activity and business activity of significance.

3.4.3 Approach

The data collected was used to address the following main themes of this section:

- Present and projected population
- Land use
- Economic activity and livelihoods
- Planned development activities
- Squatting and resettlement
- Community structure
- Employment
- Distribution of income goods and services
- Recreation

- Public Health, community health safety and facilities
- Cultural aspirations and attitudes
- Public perception.

3.4.4 Public Consultation

The National Environment and Planning Agency (NEPA) normally requests a public meeting to present the findings of the EIA. This takes the form of a large community meeting which must be preceded by a requisite twenty-one day notification period in the media, and letters of invitation to stakeholders, Non-Governmental Organizations (NGOs), Government agencies and the community. During the notification period, copies of the EIA Report will be made available for public review at the Parish Council Office, the Parish Library, the Documentation Centre at NEPA and the office of the project proponent. The meeting will be recorded verbatim and a separate report prepared for submission to NEPA. This report contains relevant information on the proof of notification of the meeting (such as newspaper advertisements); the list of invitees; the agenda; any presentations made; and the question and answer session. At the end of the public meeting, the public is given a thirty-day period in which to send comments to NEPA. In addition to the EIA Report, NEPA and its sister agencies will review the Report of the Public Meeting and any comments received before making a decision on issuing a permit.

A public consultation was already held to support the EIA that was completed in 2007. Given the adjustments in the highway alignment, this EIA represents an Addendum EIA. Based on guidelines provided by NEPA for this Addendum two subsequent public consultations (Manchester and Clarendon) are currently being planned for March, 2017.

The public must be notified at least one (1) week before the date of the public presentation and a copy of the Draft Final Addendum will be placed at the Parish Libraries and Parish Councils of Clarendon and Manchester. The Consultant will ensure that in addition to specific invitation letters; at least one (1) notice is placed in one of the most widely circulated newspapers advertising the event. The notice shall also be forwarded to NEPA for posting on its website. The Consultant will submit to NEPA a copy of the verbatim report of the public meeting within seven (7) days of the date of the meeting.

3.4.5 Heritage Assessment

Consultations were held with the Jamaica National Heritage Trust to determine if there were any critical heritage features along the alignment. Additionally, site visits and a literature review were conducted through archival material and secondary data sources (newspaper archives, Internet sources, etc.). The findings are presented in Section 5.3.

3.5 PREDICTION OF POTENTIAL IMPACTS

The various aspects of the project and the potential impacts on/interaction with the physical, biological and socioeconomic environment were identified and an Impact Matrix was developed. Aspects noted for consideration include the following:

i. Air quality and noise impacts from the highway construction and operation
ii. Drainage and flooding, particularly with respect to the rivers and other drains that the highway crosses
iii. Elevated flooding as a result of the development
iv. Water quality impacts on nearby rivers, particularly during the construction period
v. Seismic risk
vi. Slope instability and erosion
vii. Loss of habitat and loss of bird life
viii. Access to communities during construction
ix. Relocation of residents within and close to alignment
x. Adequate alternative route for Melrose Bypass
xi. Cumulative impacts of the project along with other existing or planned developments.

Impacts were identified based on the following factors:

- Duration: short, medium or long-term
- Direction: positive or negative
- Magnitude: major of minor
- Type: reversible or irreversible.

The relevant aspects of the existing environment that may impact the project were discussed accordingly. This is particularly applicable to natural hazard risk.

3.6 LIMITATIONS TO THE STUDY

Preliminary drawings were available to the consultant and although this may be considered a limitation with respect to final detail, it may also facilitate any modification that may be deemed necessary given the findings of the environmental assessment.

Secondly, a non-random survey of 300 respondents in an area population of 25,000 was completed. Although the findings would only be representative of the sample surveyed, the Consultants are confident that, given the nature of the issues probed, useful management information was derived.

4 THE EXISTING ENVIRONMENT

4.1 PHYSICAL ENVIRONMENT

4.1.1 Climate and Rainfall

Jamaica's rainfall pattern is bimodal (see Figure 4.1 to Figure 4.3) with rainfall peaks occurring in May and October and the drier periods occur in February/March and July. Climate change is expected to cause increasing variability and unpredictability in rainfall patterns leading to more protracted dry periods and more short duration high intensity rainfall in some instances. Describe what graphs for Manchester and Clarendon show and refer to extreme events described in 4.1.7.

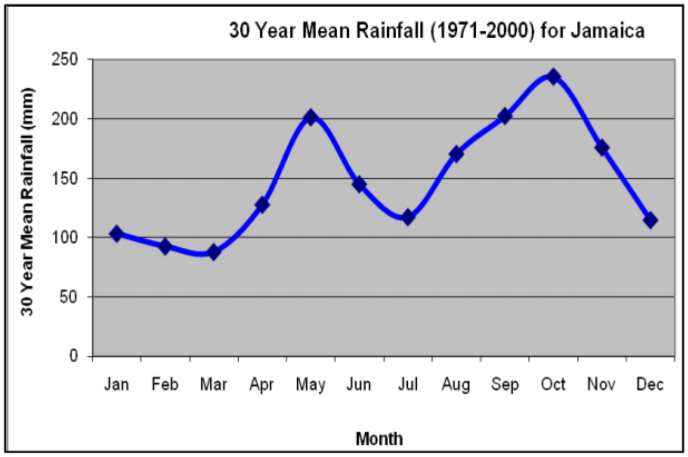


Figure 4.1: Mean Rainfall Pattern from 1971 – 2000 for entire Jamaica (Met Services)

The 30-year mean rainfall patterns are presented below for the parishes of Clarendon and Manchester (all rainfall depths are in mm).

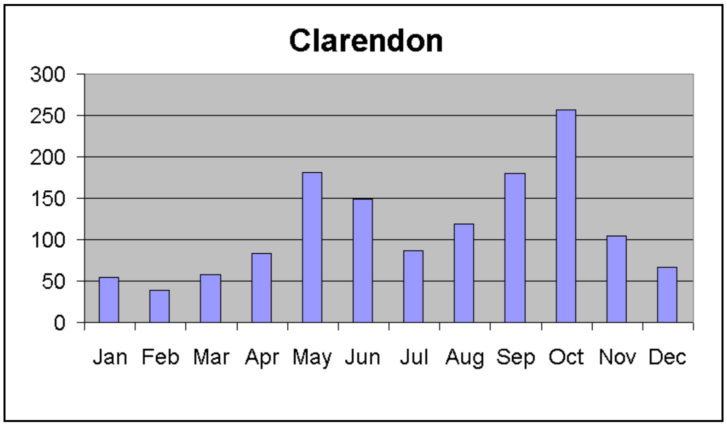


Figure 4.2: Thirty-year Mean for Clarendon

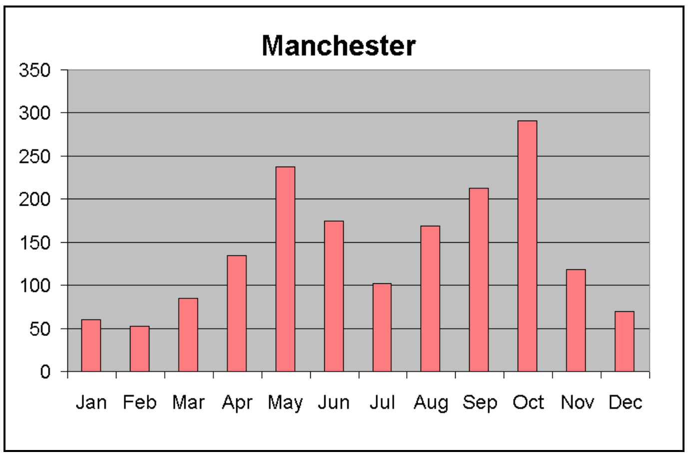


Figure 4.3: Thirty-year Mean for Manchester

4.1.2 Study Area and Zone of Influence

The study area was outlined fully in Section 1.2.1. The highway construction is approximately 28.267km long (realigned segment 19.5km) and is a 4-lane access controlled, tolled motorway with grade separated interchanges and intersections. It represents at extension of the existing highway to Williamsfield.

It is expected zone of influence is shown in Figure 4.4. The zone of influence considered and assessed during the project was a 1km, 2km and 3km buffer zone around the alignment. It is anticipated that commercial, industrial and residential land uses within the area will be impacted by the development at varying levels.

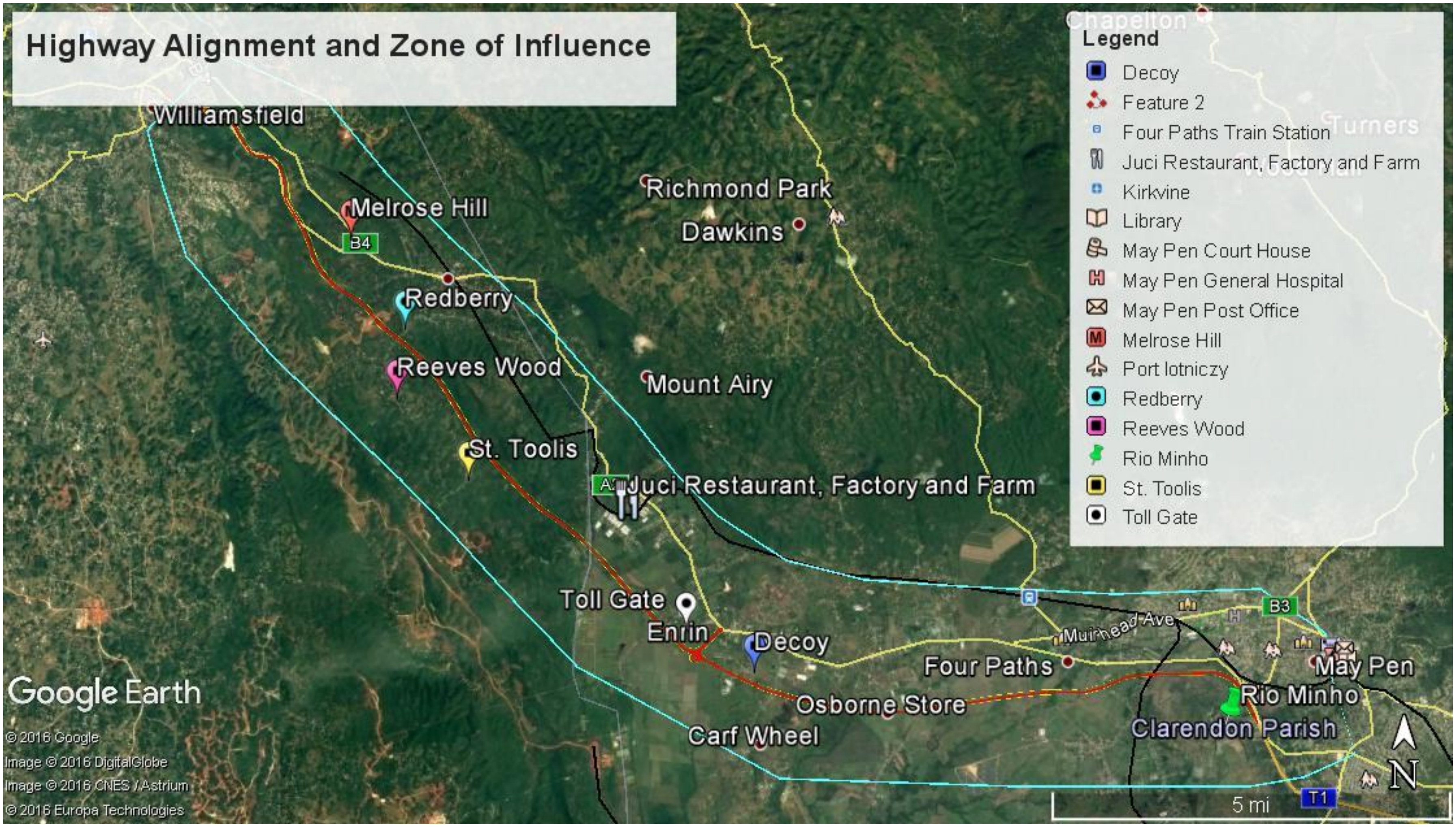


Figure 4.4: Study Area and Zone of Influence

4.1.3 Air Quality

The particulates of greatest concern to humans are those with internal diameter below 10 microns, generally referred to as respirable particulates. Respirable particulates on undeveloped lands are generally from a combination of natural and anthropogenic sources such as pollen, crashing waves, roadside dust, and smoke from vegetation and wood burning or vegetation clearing.

The results of the air quality sampling exercise conducted in December are presented in Table 4.1 below. Air quality monitoring was conducted at eight (8) locations along the perimeter of property and at one location in the middle of the property. The data obtained will be useful for providing an indication of baseline levels which should be maintained during construction and operation of the proposed highway.

Table 4.1: Respirable Air Quality Data

LOCATION	Particulate Matter Concentration (PM_{10}) (μgm^{-3}) for 24 hour period			Total PM_{10} Concentration over 72 hours (μgm^{-3})	NRCA Particulate Matter Concentration (μgm^{-3}) for 24 hour Period
DATES	13-14/12/16	14-15/12/16	15-16/12/16		
Four Paths	7.1	18.2	21.7	**46.9**	**150**
Denbigh Drive	21.5	6.6	16.3	**44.4**	
Decoy at Toll Gate	13.9	16.4	13.0	**43.3**	
Duke Street	20.5	2.8	11.1	**34.3**	
Community Centre	26.7	22.9	10.6	**60.1**	
Redberry	23.2	27.6	14.8	**65.6**	
Trinity	78.5	19.0	21.6	**119.0**	
Hope Village	119.3	12.3	23.7	**155.3**	

The results indicate that the particulate matter (PM_{10}) concentrations on the site were within the NEPA 24-hour guideline of 150μgm^{-3} for each day measurements were done. The PM_{10} levels, on average, were below 27 μgm^{-3} for all the areas tested, except for Trinity and Hope Village on day one of the assessment. Hope Village exceeded the standard NRCA 24-hour standard for the cumulative concentration over 72 hours. The PM $_{10}$ concentration at this sampling location for day one was very high when compared to other sampling days. It was observed that maintenance work was being done on the property adjacent to the sampling site. Any activities such as burning or clearing of the land will increase the levels of airborne particulates. The monitor placed at Trinity was also in an area where human activities may have influenced the elevated PM_{10} concentrations measured on day one of the assessment.

The low PM_{10} levels measured at Duke Street on day two of the assessment may be due to rainfall in the area. Rain acts as a natural sink for airborne particulate matter.

SOx and NOx were conducted as a part of the 2007 EIA and results were well within the limits established in the National Ambient Air Quality Standard for nitrogen and sulphur dioxide. It is not anticipated that these values would be any higher and so tests were not re-conducted. Unless we anticipate lengthy traffic jams and little to no winds on the highway (highly unlikely), the impact from these pollutants would be minimal.

4.1.4 Noise

This section outlines the results of the seventy-two (72) hour noise monitoring exercise at the seven (7) monitoring stations. Table 4.2 shows a summary of results of the noise assessment conducted.

Table 4.2: Summary Results of Noise Assessment

STATION	Lmin (dBA)	Lmax (dBA)	L_{Aeq} (72h) (Avg)	GEOMETRIC MEAN FREQUENCY (Hz)	OCTAVE BAND (Hz)
York Town Road Four Paths (AQ 1) Noise (Station 1)	31.6	96.5	63.3	63	56-71
Denbigh Drive (AQ 2) Noise (Station 2)	31.8	88.5	52.7	63	56-71
Decoy at Toll Gate (AQ 3) Noise (Station 3)	27.8	88.8	53.8	63	56-71
Duke Street (AQ 4) Noise (Station 4)	28.8	92.5	55.1	31.5	28-35
St. Jago Road - Community Centre (AQ 5) Noise (Station 5)	29.3	80.6	49.4	50 & 63	45-56 & 56-71
Redberry (AQ 6) Noise (Station 6)	26.0	89.7	57.1	63	56-71
Trinity (AQ 7) Noise (Station 7)	26.7	70.6	51.5	6300	5615-7069

4.1.4.1 Comparisons with NEPA and FHA Guidelines and Standards

NEPA Guidelines

Comparison of the ambient noise levels in the study area with the National Environmental and Planning Agency (NEPA) guidelines are shown in Table 4.3, according to the various zones. It is assumed that all seven noise monitoring stations are located in residential areas.

Stations 1 (York Town road to Four Paths), 3 (Decoy at Toll Gate), 4 (Duke Street) and 6 (Redberry) were all non-compliant with the 55 dBA NEPA noise guidelines during the daytime (7am – 10 pm). During the night-time, Stations 1, 2 and 4 were non-compliant with the 50 dBA NEPA night-time noise guidelines.

Station 2 (Denbigh Drive) was the only location to have night-time noise levels higher than the daytime noise levels. This is possibly due to natural night-time noise sources, such as, crickets chirping etc.

Table 4.3: Comparison of Noise Levels at the Stations with the NEPA Daytime and Night-time Guidelines

STN #	ZONE	Daytime 7 am. - 10 pm. (dBA)	NEPA Daytime Guideline (dBA)	Night-time 10 pm. - 7 am. (dBA)	NEPA Night-time Guideline (dBA)
York Town Road Four Paths Noise (Station 1)	Residential	64.9	55	57.6	50
Denbigh Drive Noise (Station 2)	Residential	52.2	55	53.6	50
Decoy at Toll Gate Noise (Station 3)	Residential	55.5	55	47.5	50
Duke Street Noise (Station 4)	Residential	55.5	55	54.6	50
St. Jago Road - Community Centre Noise (Station 5)	Residential	50.1	55	48.1	50
Redberry Noise (Station 6)	Residential	58.9	55	49.8	50
Trinity Noise (Station 7)	Residential	53.4	55	41.8	50

NB. Values in red are non-compliant with the NEPA standards/guidelines

FHA Standards

Noise standards issued by the Federal Highway Administration (FHA) of the United States Department of Transportation for use by state and Federal highway agencies in the planning and design of highways, are depicted below in Table 4.4.

Table 4.4: FHA Noise Standards for Use by State and Federal Highway Agencies for Planning and Design of Highways

Land Use Category	Design Noise Level-L10	Description of Land Use Category

Land Use Category	Design Noise Level-L10	Description of Land Use Category
A	**60dBA** (Exterior)	Tracts of lands in which serenity and quiet are of extraordinary significance and serve an important public need, and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose Such areas could include amphitheatres, particular parks or portions of parks, or open spaces which are dedicated or recognized by appropriate local officials for activities requiring special qualities of serenity and quiet.
B	**70dBA** (Exterior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, picnic areas, recreation areas, playgrounds, active sports areas, and parks
C	**75dBA** (Exterior)	Developed lands, properties or activities not included in categories A and B above
D	–	For requirements on undeveloped lands see paragraphs 5a(5) and (6), this PPM[4]
E	**55dBA** (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals and auditoriums

Based on the land use categories listed above, **Category B** is the most apt to describe the land use within the study area of the noise assessment.

Comparisons with the FHA standard (Category B) has indicated that of the 72 hours, the L10 noise levels at all stations excepting for Stations 1, 2 and 6 were in full compliance with the FHA standard (Figures 22 – 28). Stations 1, 2 and 6 complied with the FHA standard 98.6% of the 72-hour time period.

[4] Parts per million (PPM)

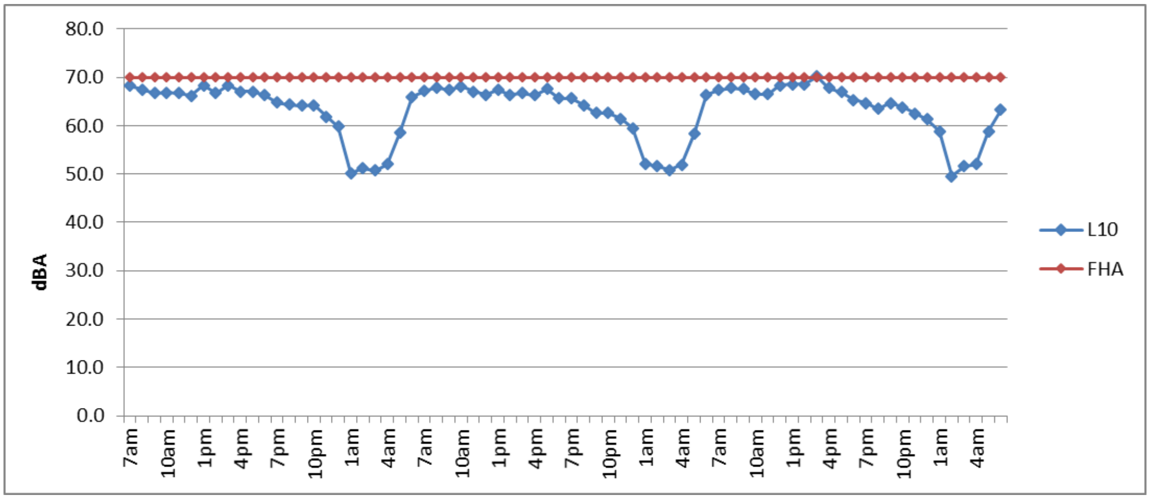


Figure 4.5: Comparison of L10 at Station 1 with FHA Standard

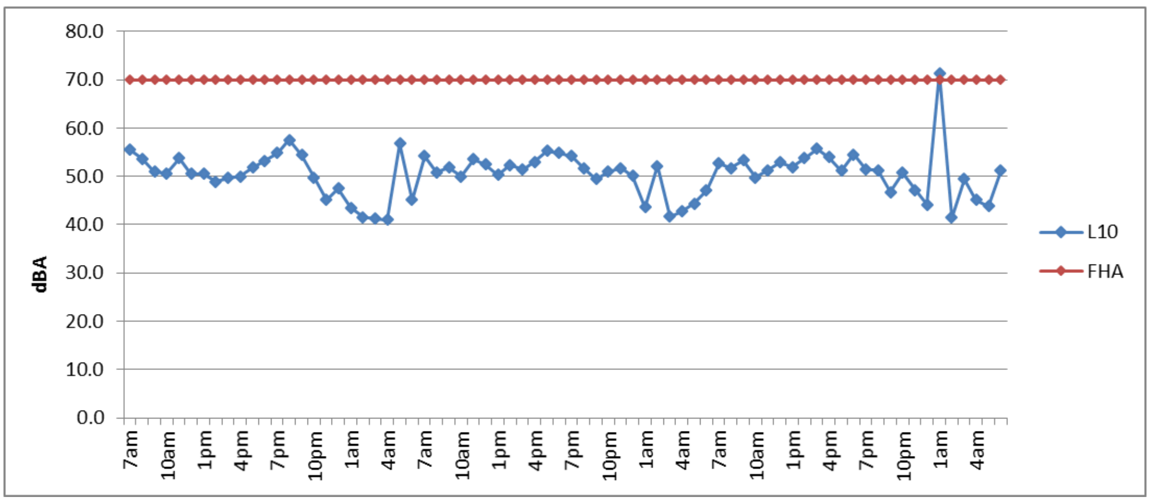


Figure 4.6: Comparison of L10 at Station 2 with FHA Standard

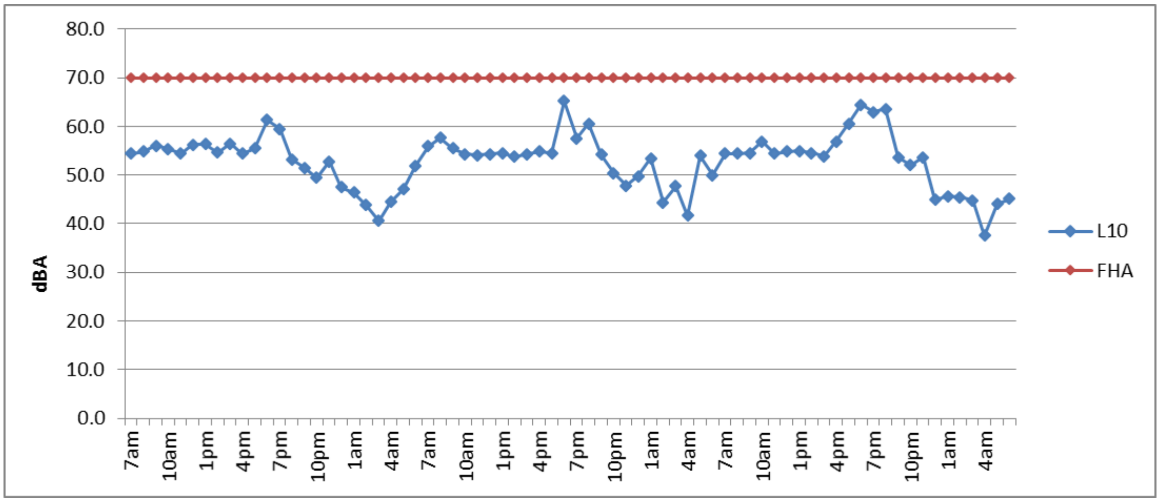


Figure 4.7: Comparison of L10 at Station 3 with FHA Standard

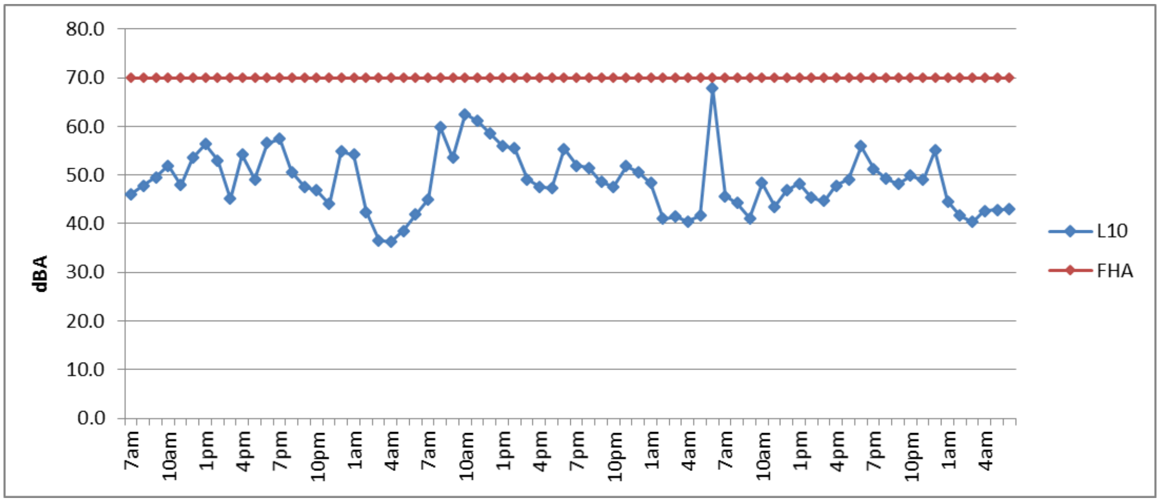


Figure 4.8: Comparison of L10 at Station 4 with FHA Standard

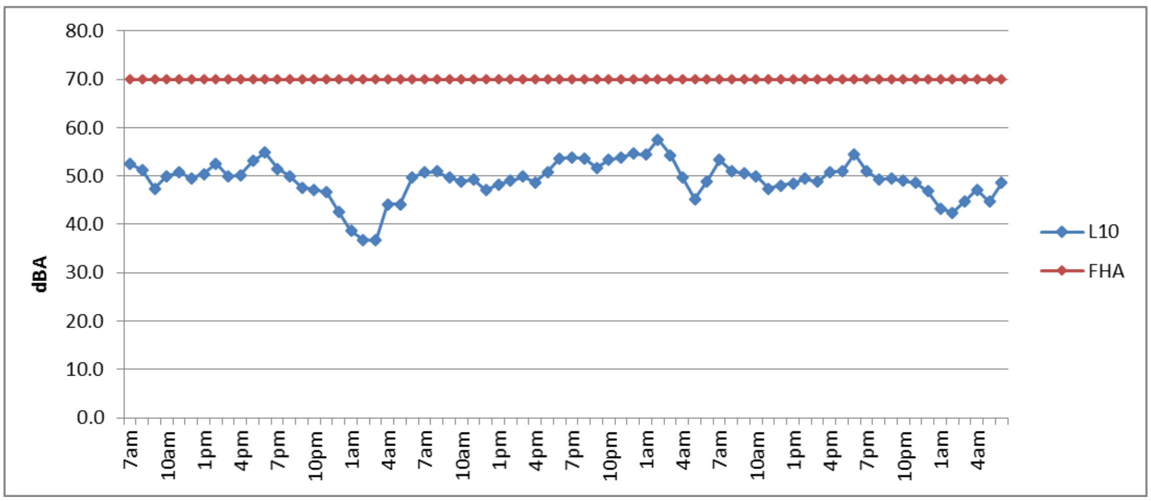


Figure 4.9: Comparison of L10 at Station 5 with FHA Standard

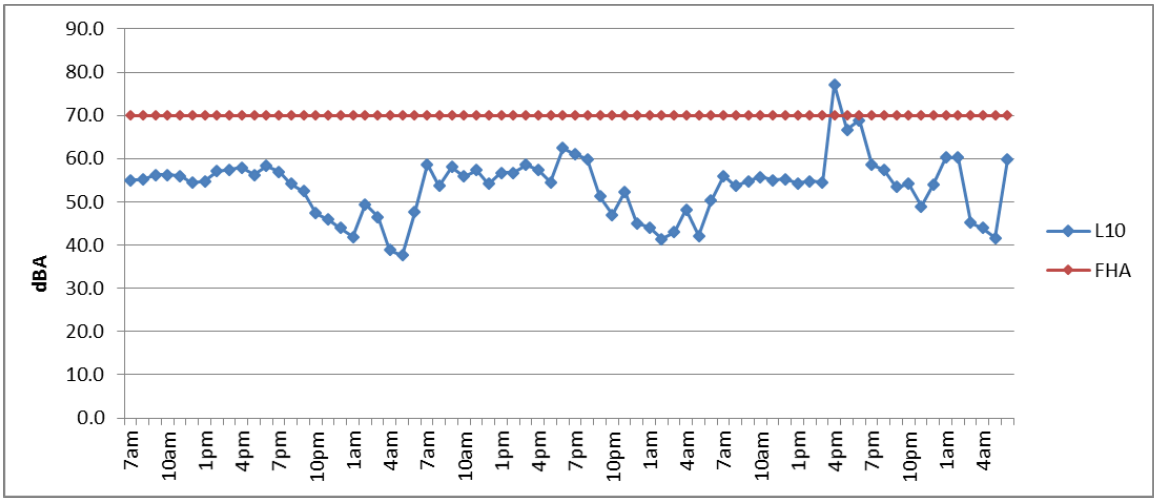


Figure 4.10: Comparison of L10 at Station 6 with FHA Standard

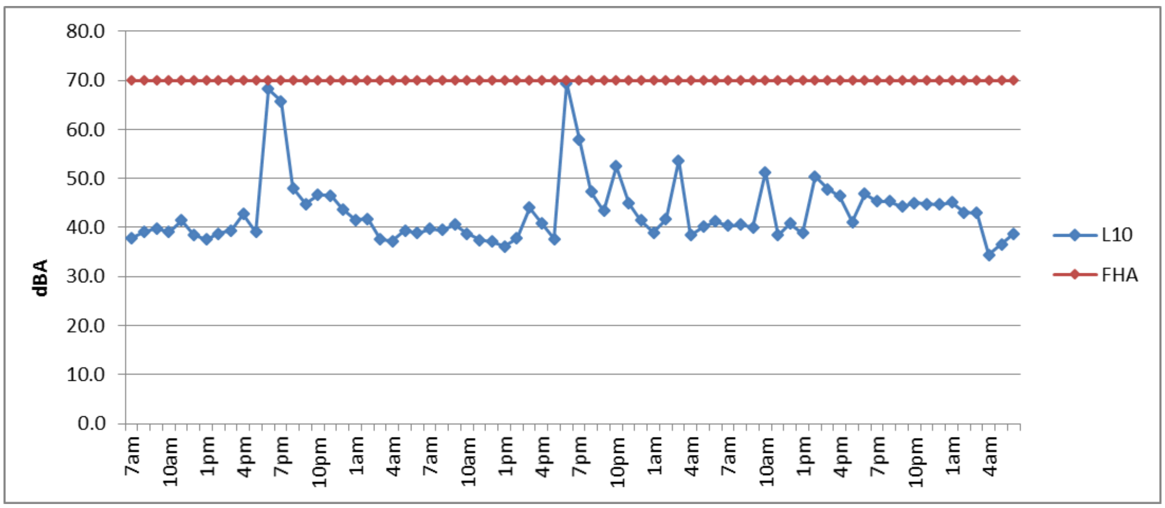


Figure 4.11: Comparison of L10 at Station 7 with FHA Standard

Noise Assessment Details

Station 1 (York Town road to Four Paths)

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 31.6 dBA to a high (Lmax) of 96.5 dBA. Average noise level for this period was 63.3 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4.12.

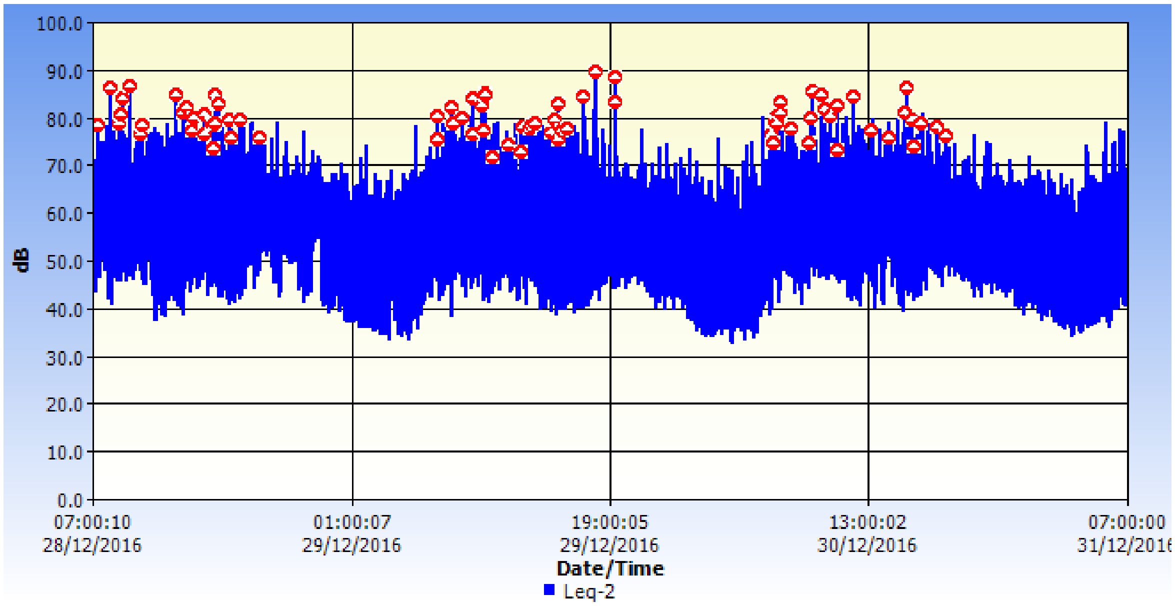


Figure 4.12: Noise fluctuation (Leq) over 72 hours at Station 1

Octave Band Analysis at Station 1

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz. (octave frequency range is 56 - 71 Hz) (Figure 4.13). Although the noise was centred around the 63 Hz frequency, there was also noise emitted in the 160 Hz frequency.

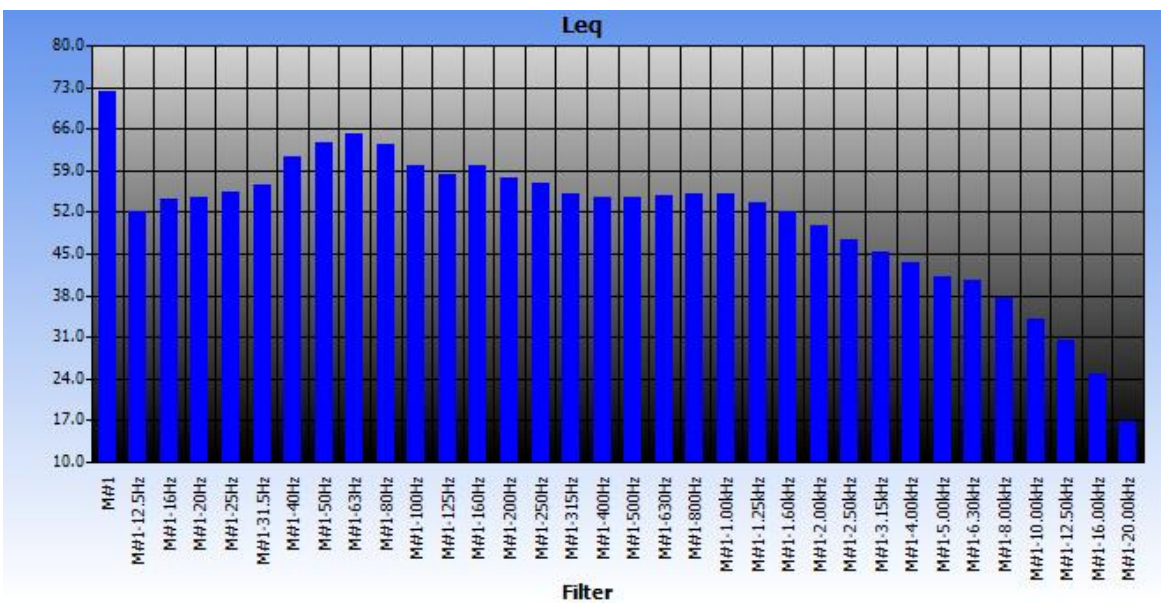


Figure 4.13: Octave band spectrum of noise at Station 1

L10 and L90

The two most common L_n values used are L_{10} and L_{90} and these are sometimes called the 'annoyance level' and 'background level' respectively. L_{10} is almost the only statistical value used for the descriptor of the higher levels, but L_{90}, is widely used to describe the ambient or background level. L10-L90 is often used to give a quantitative measure as to the spread or "how choppy" the sound was.

L10 is the noise level exceeded for 10% of the time of the measurement duration. This is often used to give an indication of the upper limit of fluctuating noise, such as that from road traffic. L90 is the noise level exceeded for 90% of the time of the measurement duration.

The difference between L10 and L90 gives an indication of the noise climate. When the difference is < 5 dBA then it is considered that there are no significant fluctuations in the noise climate, moderate fluctuations 5-15 dBA and large fluctuations >15 dBA.

Figure 4.14 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈9.7% of the time) and large fluctuations (L10 – L90) (≈90.3% of the time) in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 66 dBA and 41.8 dBA respectively.

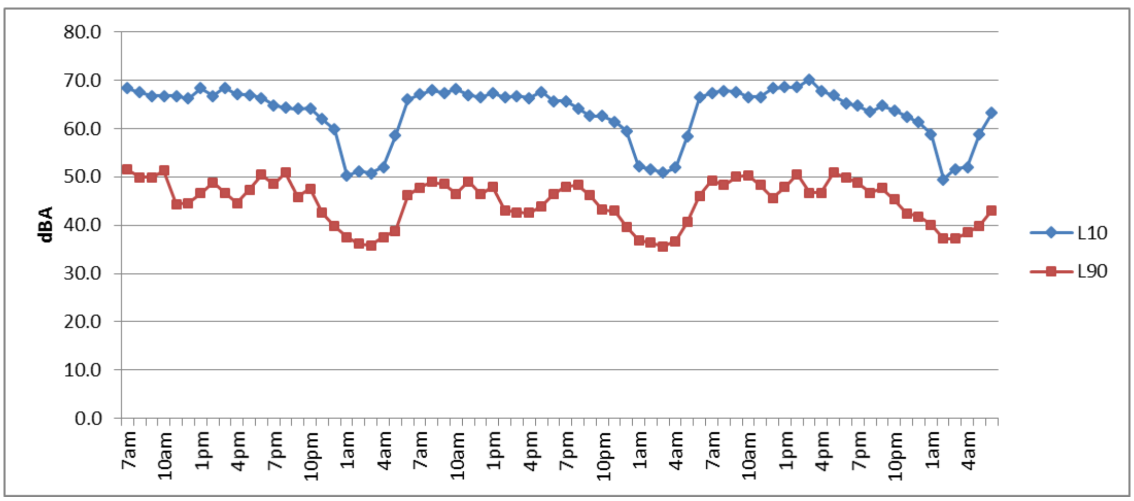


Figure 4.14: L10 and L90 for Station 1

STATION 2 (Denbigh Road)

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 31.8 dBA to a high (Lmax) of 88.5 dBA. Average noise level for this period was 52.7 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4.15.

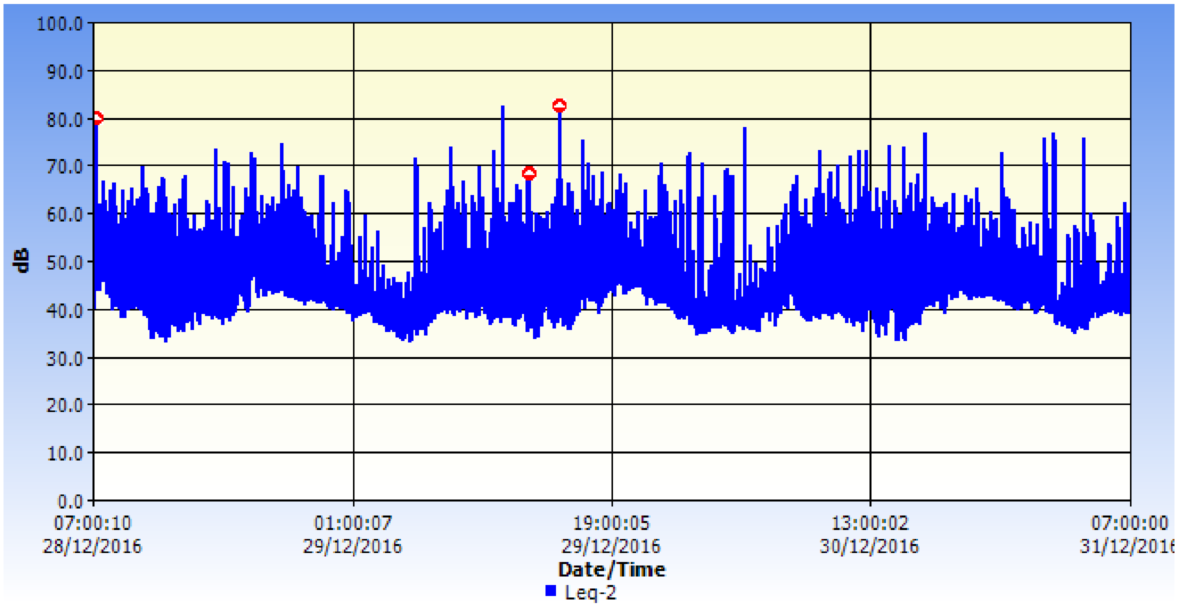


Figure 4.15: Noise fluctuation (Leq) over 72 hours at Station 2

Octave Band Analysis at Station 2

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz. (octave frequency range is 56 - 71 Hz) (Figure 4.16). Although the noise was centred around the 63 Hz frequency, there was also noise emitted in the 630 Hz and 6.3kHz frequencies.

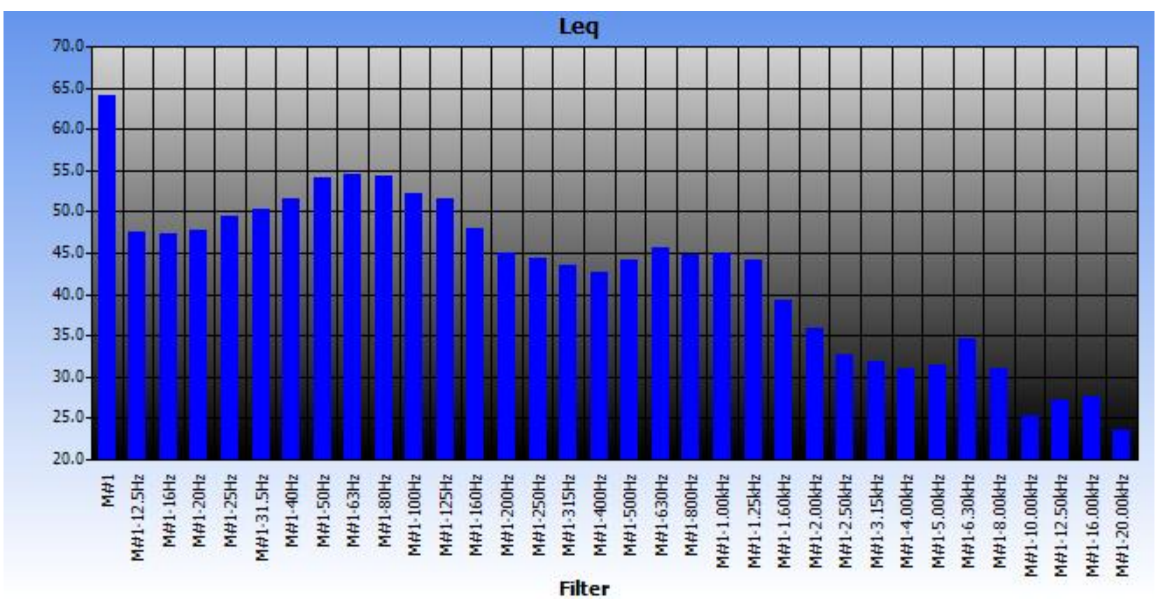


Figure 4.16: Octave band spectrum of noise at Station 2

L10 and L90

Figure 4.17 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈79.19% of the time), large fluctuations (L10 – L90) (≈11.11% of the time) and no significant fluctuation (L10 – L90) (≈9.7% of the time), in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 51.3 dBA and 37.9 dBA respectively.

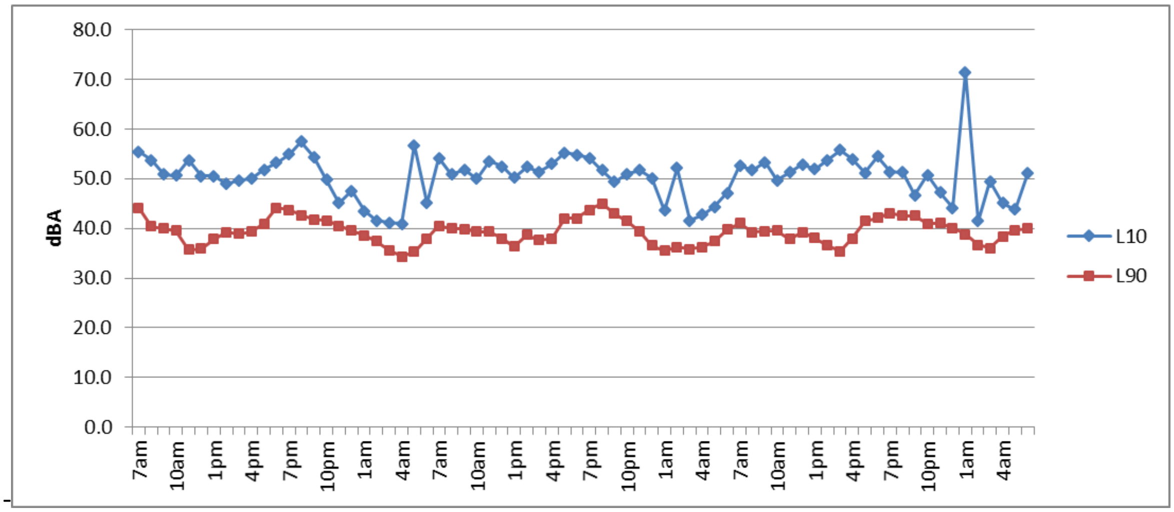


Figure 4.17: L10 and L90 for Station 2

STATION 3 (Decoy at Toll Gate)

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 27.8 dBA to a high (Lmax) of 88.8 dBA. Average noise level for this period was 53.8 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4.18.

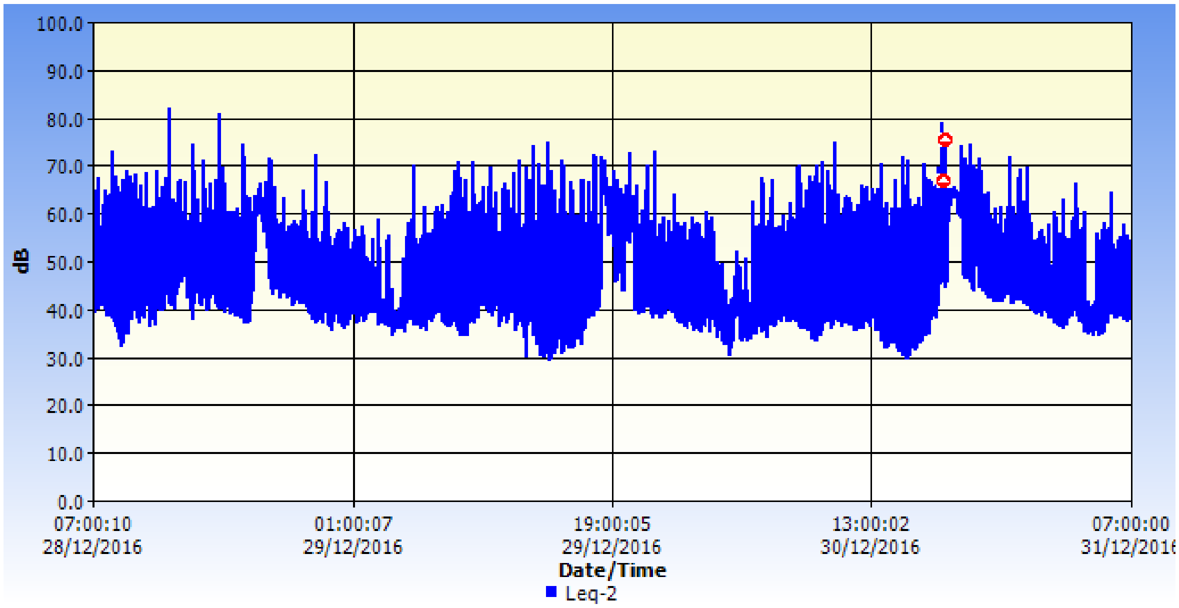


Figure 4.18: Noise fluctuation (Leq) over 72 hours at Station 3

Octave Band Analysis at Station 3

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz. (octave frequency range is 56 - 71 Hz) (Figure 4.19). Although the noise was centred around the 63 Hz frequency, there was also noise emitted in the 6.3 kHz and 8 kHz frequencies.

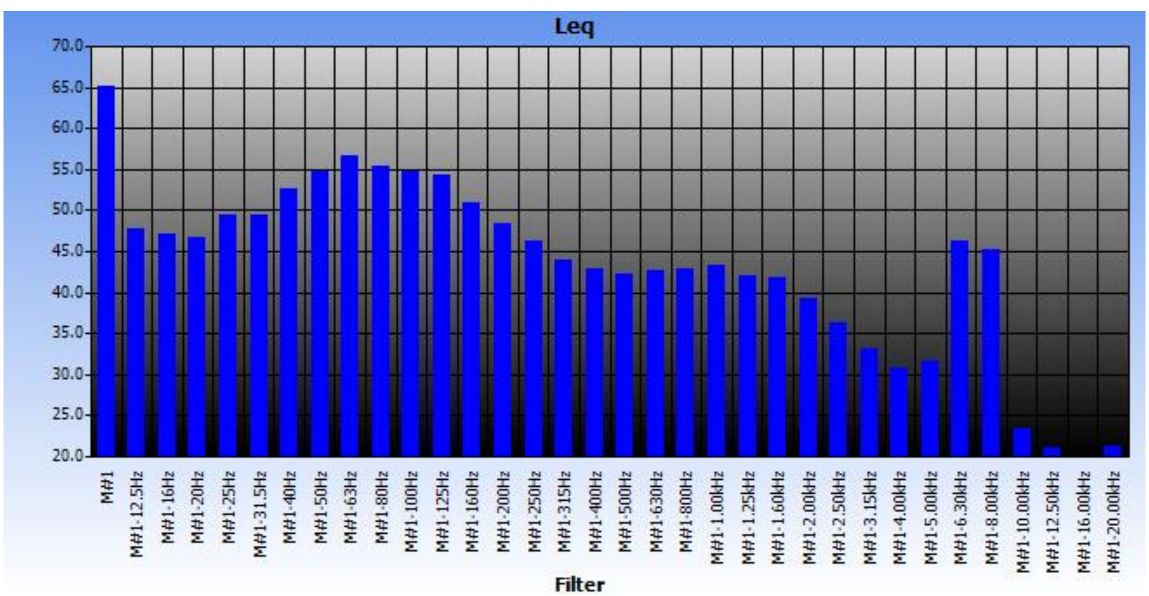


Figure 4.19: Octave band spectrum of noise at Station 3

L10 and L90

Figure 4.20 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈55.53% of the time), large fluctuations (L10 – L90) (≈41.67% of the time) and no significant fluctuation (L10 – L90) (≈2.8% of the time), in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 56.4 dBA and 37 dBA respectively.

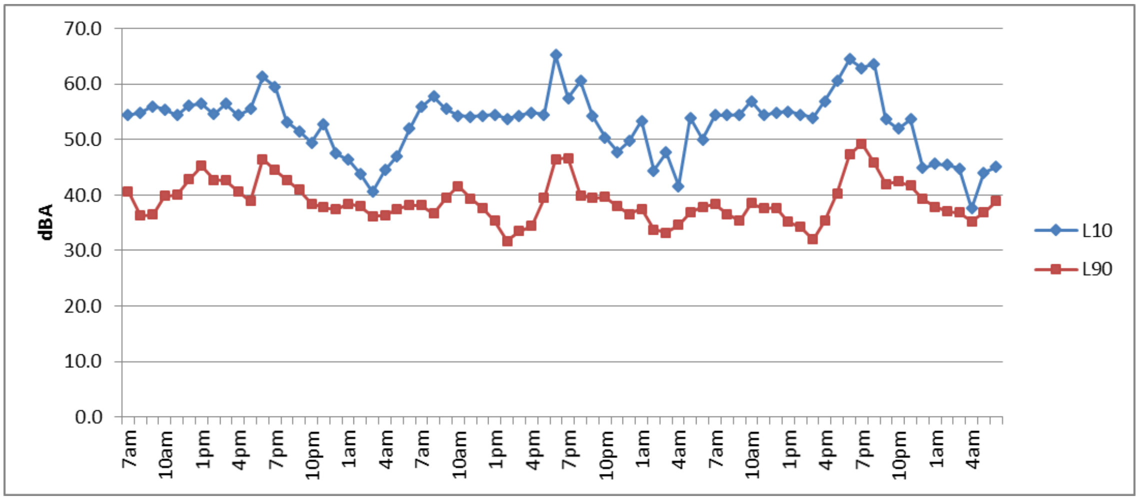


Figure 4.20: L10 and L90 for Station 3

STATION 4 (Duke Street)

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 28.8 dBA to a high (Lmax) of 92.5 dBA. Average noise level for this period was 55.1 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4.21.

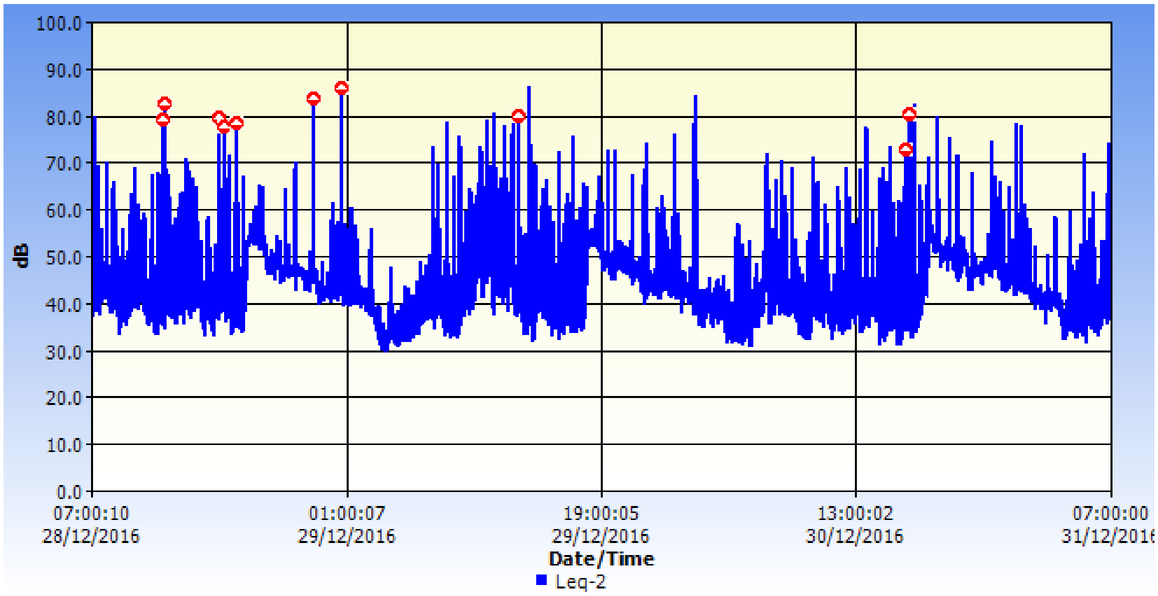


Figure 4.21: Noise fluctuation (Leq) over 72 hours at Station 4

Octave Band Analysis at Station 4

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 31.5 Hz. (octave frequency range is 28 - 35 Hz) (Figure 4.22). Although the noise was centred around the 31.5 Hz frequency, there was also noise emitted in the 40 Hz, 500 Hz, 630 Hz, 6.3 kHz and 8 kHz frequencies.

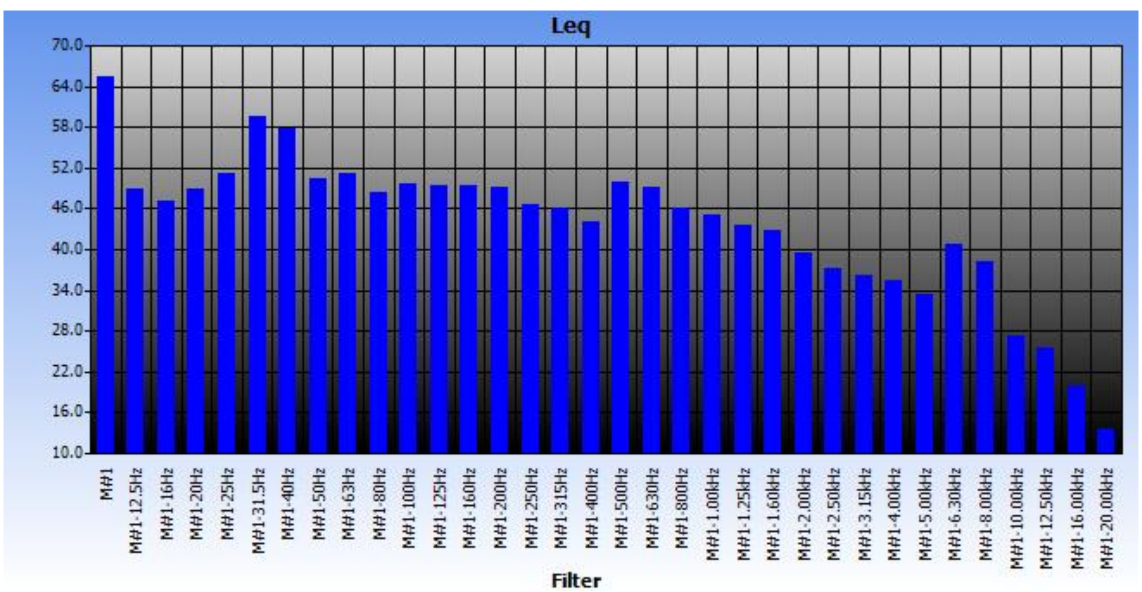


Figure 4.22: Octave band spectrum of noise at Station 4

L10 and L90

Figure 4.23 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈59.72% of the time), large fluctuations (L10 – L90) (≈16.67% of the time) and no significant fluctuation (L10 – L90) (≈23.61% of the time), in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 52.6 dBA and 35.4 dBA respectively.

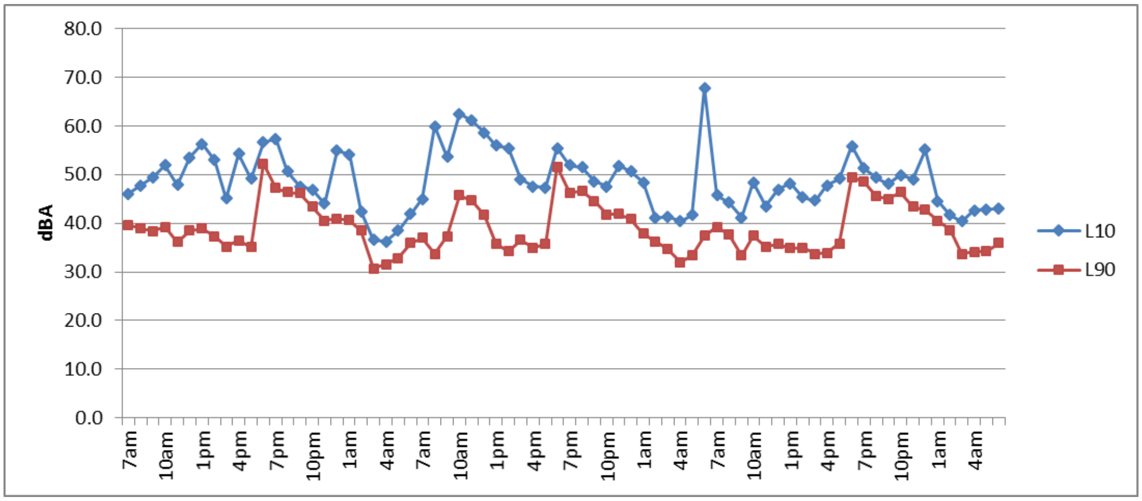


Figure 4.23: L10 and L90 for Station 4

STATION 5 (St. Jago Road -Community Centre)

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 29.3 dBA to a high (Lmax) of 80.6 dBA. Average noise level for this period was 49.4 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4.24.

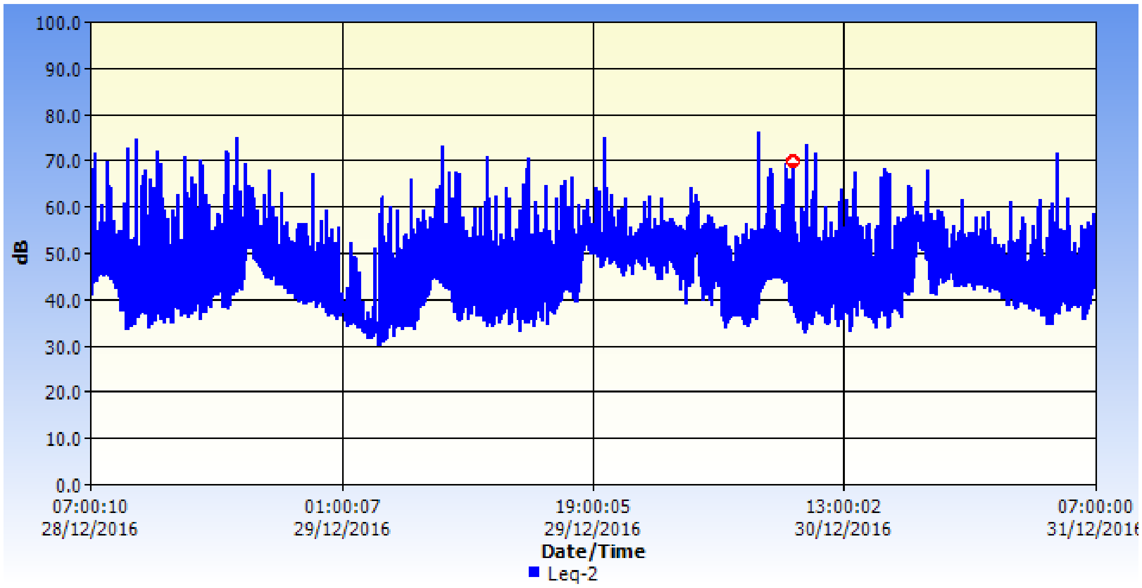


Figure 4.24: Noise fluctuation (Leq) over 72 hours at Station 5

Octave Band Analysis at Station 5

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequencies of 50 Hz and 63 Hz. (octave frequency ranges 45-56 Hz and 56 - 71 Hz respectively) (Figure 4.25). Although the noise was centred around the 50 Hz and 63 Hz frequencies, there was also noise emitted in the 6.3 kHz and 12.5 kHz frequencies.

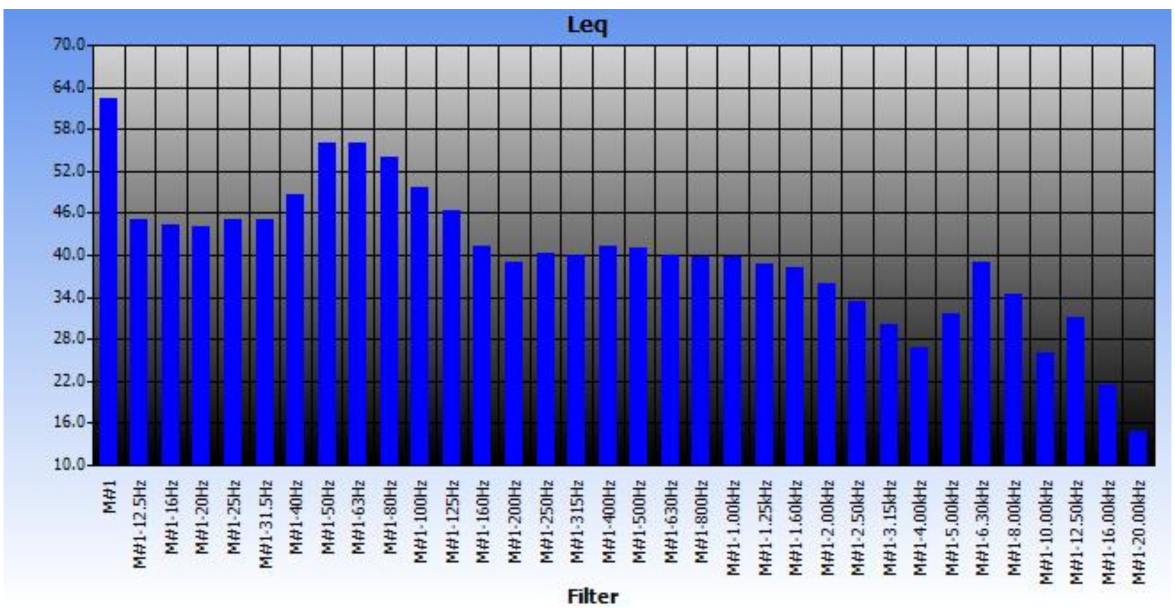


Figure 4.25: Octave band spectrum of noise at Station 5

L10 and L90

Figure 4.26 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈91.7% of the time) and no significant fluctuation (L10 – L90) (≈8.3% of the time), in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 52 dBA and 36.9 dBA respectively.

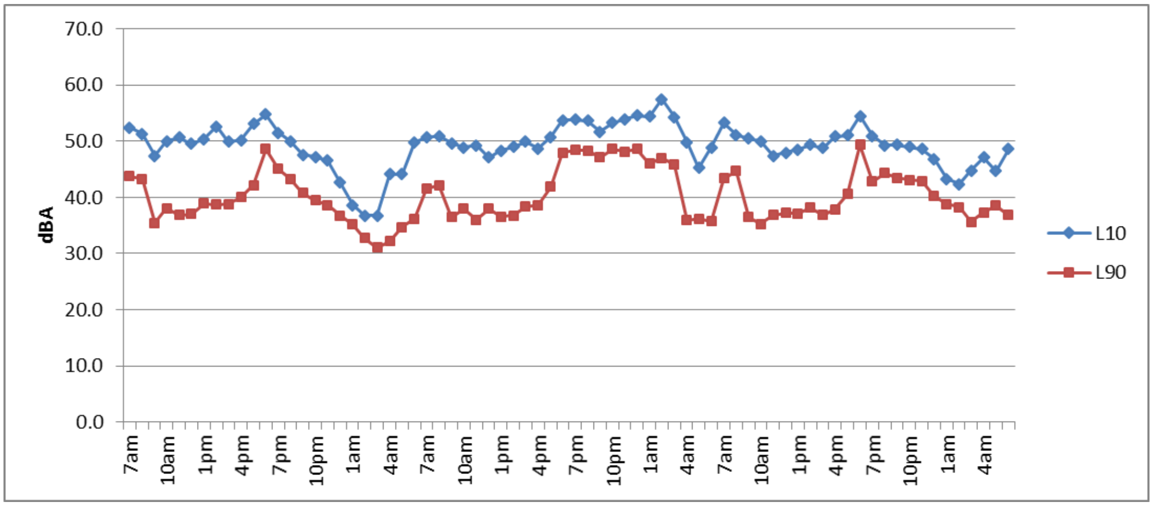


Figure 4.26: L10 and L90 for Station 5

STATION 6 (Redberry)

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 26 dBA to a high (Lmax) of 89.7 dBA. Average noise level for this period was 57.1 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4.27.

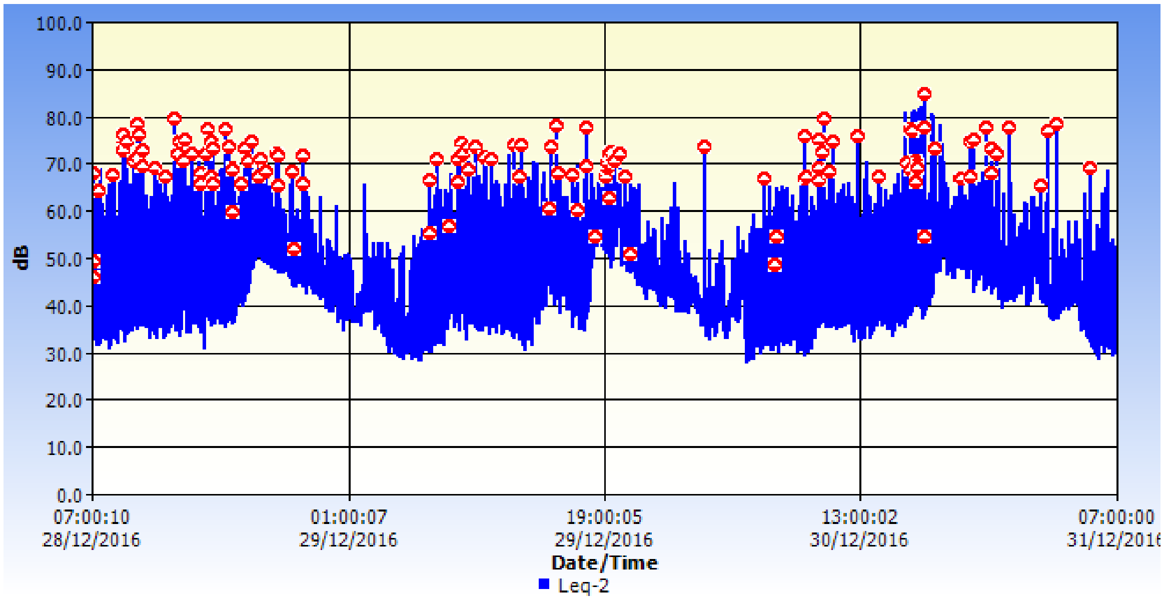


Figure 4.27: Noise fluctuation (Leq) over 72 hours at Station 6

Octave Band Analysis at Station 6

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz. (octave frequency range is 56 - 71 Hz) (Figure 4.28). Although the noise was centred around the 63 Hz frequency, there was also noise emitted in the 31.5 Hz and 6.3 kHz frequencies.

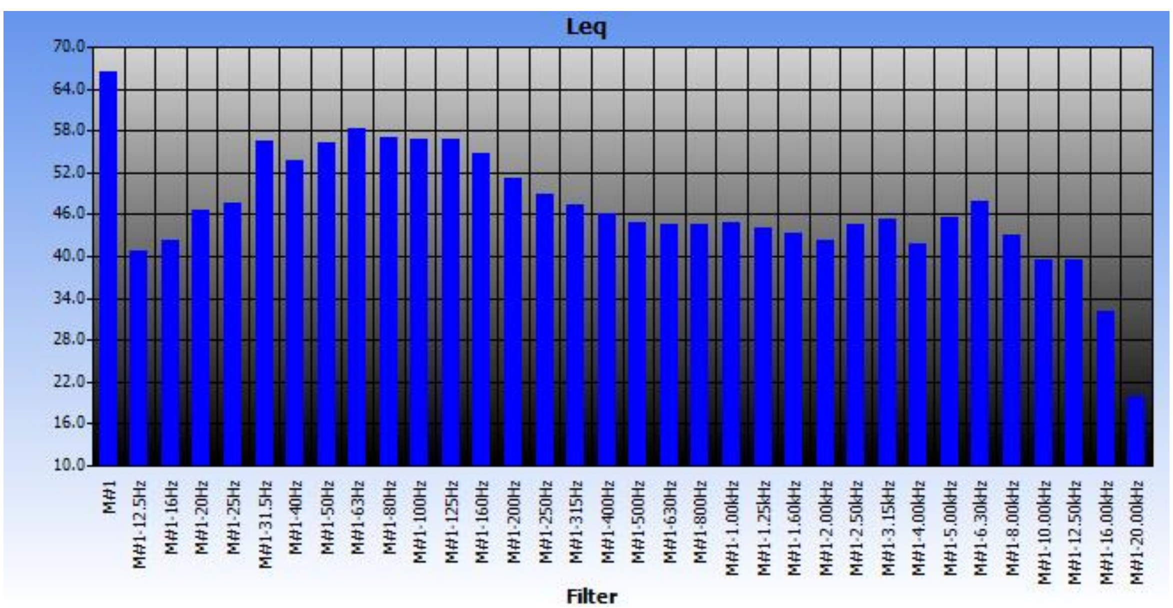


Figure 4.28: Octave band spectrum of noise at Station 6

L10 and L90

Figure 4.29 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈40.3% of the time), large fluctuations (L10 – L90) (≈52.8% of the time) and no significant fluctuation (L10 – L90) (≈6.9% of the time), in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 55.8 dBA and 35.3 dBA respectively.

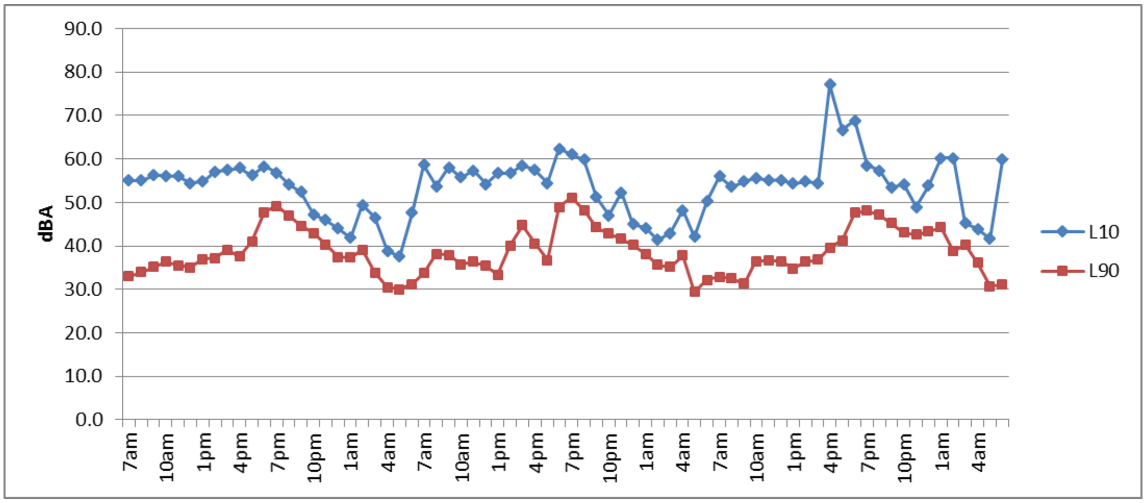


Figure 4.29: L10 and L90 for Station 6

STATION 7 (Trinity road)

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 26.7 dBA to a high (Lmax) of 70.6 dBA. Average noise level for this period was 51.5 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 4.30.

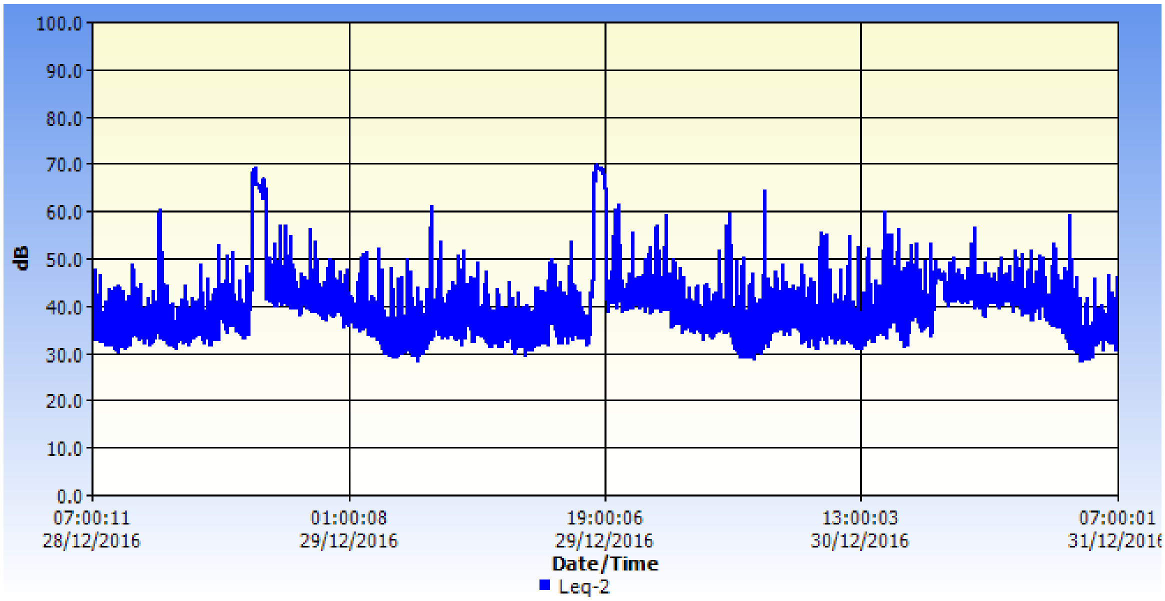


Figure 4.30: Noise fluctuation (Leq) over 72 hours at Station 7

Octave Band Analysis at Station 7

The noise at this station during the 72 hour period was in the high frequency band centred around the geometric mean frequency of 6300 Hz. (octave frequency range is 5615-7069 Hz) (Figure 4.31), possibly due to a high frequency noise source in this area. Although the noise was centred around the 6300 Hz frequency, there was also noise emitted in the 63 Hz, 8 kHz and 12.5 kHz frequencies.

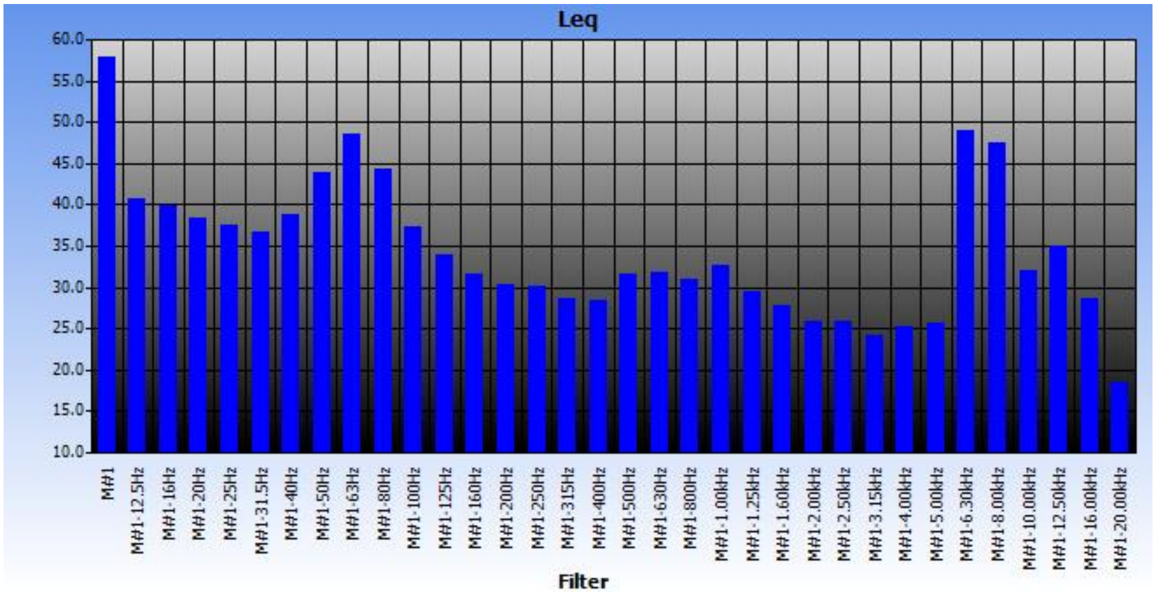


Figure 4.31: Octave band spectrum of noise at Station 7

L10 and L90

Figure 4.32 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) (≈73.61% of the time), large fluctuations (L10 – L90) (≈9.72% of the time) and no significant fluctuation (L10 – L90) (≈16.67% of the time), in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 44.7 dBA and 32.9 dBA respectively.

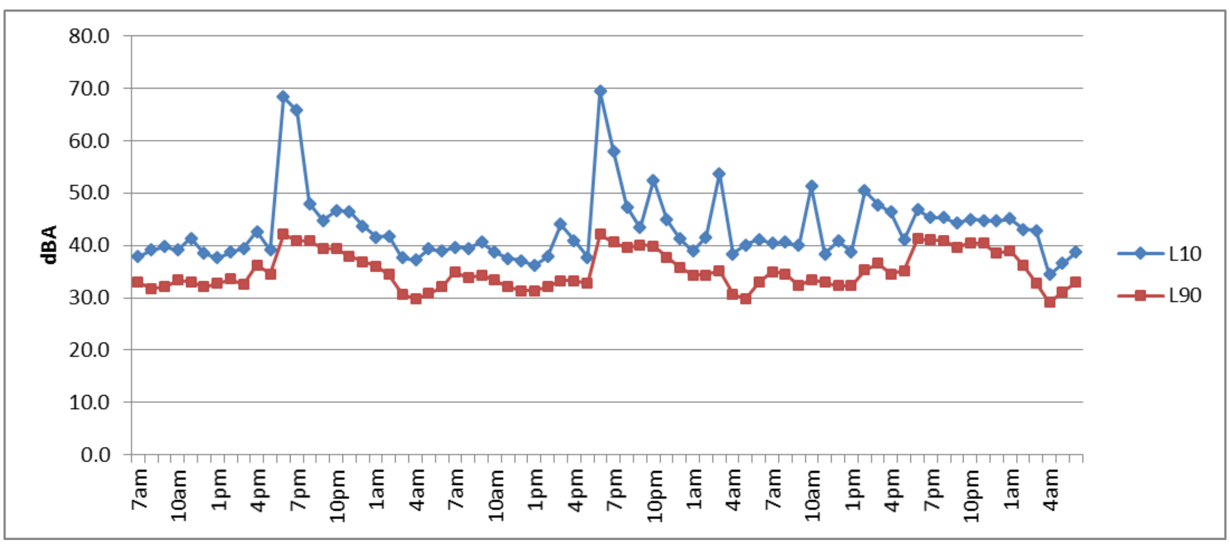


Figure 4.32: L10 and L90 for Station 7

Summary noise setting

1. Stations 1 (York town road to Four Paths), 3 (Decoy at Toll Gate), 4 (Duke Street) and 6 (Redberry) were non-compliant with the NEPA daytime guidelines;

2. Stations 1 (York Town Road to Four Paths), 2 (Denbigh Drive) and 4 (Duke Street) were compliant with the NEPA night-time guidelines;

3. Station 2 (Denbigh Drive) was the only location to have night-time noise levels higher than the daytime noise levels. This is possibly due to night-time anthropogenic noise sources such as crickets chirping, etc.;

4. The L10 for all stations, excepting Stations 1 (York Town road to Four Paths), 2 (Denbigh Drive) and 6 (Redberry), were compliant with the Federal Highway Agency's (FHA) standard of 70 dB for the 72-hour monitoring period;

5. The L10 for stations 1 (York Town road to Four Paths), 2 (Denbigh Drive) and 6 (Redberry) exceeded the Federal Highway Agency's (FHA) standard of 70 dB for 1.4% of the monitoring period;

6. All Stations, except Station 7 (Trinity road), had noise with frequencies centred around a low frequency band (12.5 – 500 Hz);

7. Station 7 (Trinity road) had noise centred around a high frequency band (6300 Hz), possibly due to a high frequency noise source in this area;

8. Five out of the seven noise stations had mostly moderate fluctuations in the noise climate. Stations 1 (York Town road to Four Paths) and 6 (Redberry) were the only two noise stations to have mostly large fluctuations in the noise climate.

4.1.5 Water Quality

The results of the water quality analyses for the surface water samples associated with the project site are presented in Table 4.5 below. The results certificates and details of the methods of analyses used are in Appendix II.

The data indicates that there is some degradation in the water quality possibly from anthropogenic activities. This is especially so for St. Anne's Gully which had elevated BOD, conductivity, total dissolved solids, sulphate and chloride levels. This Gully acts as the conduit for storm water runoff and possible trade effluent from the May Pen area. These water bodies also pass through well populated areas some of which have livestock or practise livestock rearing. Surface run-off from these areas or discharges from anthropogenic activities will negatively impact the quality of the water in these systems.

Table 4.5: Results of Surface Water Samples

PARAMETERS	SAMPLE LOCATION	NRCA

	Duke Street Upstream	**Duke Street Downstream**	**St. Anne's Gully Upstream (S.P #2)**	**St. Anne's Gully Downstream (S.P #1)**	**AMBIENT WATER STANDARD**
pH (units)	8.14	7.45	8.05	7.72	**7.00 – 8.40**
Conductivity (mS/cm)	0.368	0.409	0.720	0.800	**0.15 – 0.6**
Total Dissolved Solids (mg/L)	184	204	362	402	**120.0 – 300**
Dissolved Oxygen (mg/L)	9.55	4.99	7.05	4.66	**–**
Turbidity (NTU)	5.97	0.75	3.20	2.54	**–**
Biochemical Oxygen Demand (mg O_2/L)	1.4	2.0	2.8	2.4	**0.8 – 1.7**
Chemical Oxygen Demand (mg O_2/L)	<3	4	6	8	**–**
Total Suspended Solids (mg/L)	4.4	<2.5	2.8	<2.5	**–**
Nitrate (mg NO_3^-/L)	-	-	-	-	**0.1 – 7.5**
Nitrate as Nitrogen (mg NO_3-N/L)	<3	<3	<3	<3	**–**
Phosphate (mg PO_4^{3-}/L)	<0.2	0.05	0.31	0.50	**0.01 – 0.8**
Sulphate (mg SO_4^{2-}/L)	<1	<1	31	43	**3.0 – 10.0**
Chloride (mg Cl^-/L)	12.3	8.2	80.8	85.2	**5.0 – 20.0**
Total Coliform (MPN/100ml)	920	1600	>1600	>1600	**–**
Faecal Coliform (MPN/100ml)	79	350	280	41	**–**
Alkalinity[a] (mg/L)	N/A	N/A	N/A	N/A	**–**
Hardness[a] (mg $CaCO_3$/L)	N/A	N/A	N/A	N/A	**127.0 - 381.0**
Silica[a] (mg/L)	N/A	N/A	N/A	N/A	**5.0 – 39.0**
Potassium[a] (mg K/L)	N/A	N/A	N/A	N/A	**0.74 – 5.0**

PARAMETERS	SAMPLE LOCATION				NRCA AMBIENT WATER STANDARD
	Duke Street Upstream	Duke Street Downstream	St. Anne's Gully Upstream (S.P #2)	St. Anne's Gully Downstream (S.P #1)	
Lead[a] (mg Pb/L)	N/A	N/A	N/A	N/A	–
Mercury[a] (mg Hg/L)	N/A	N/A	N/A	N/A	–
Arsenic[a] (mg As/L	N/A	N/A	N/A	N/A	–
Total Petroluem Hydrocarbons (mg/L)	<5.0	<5.0	<5.0	<5.0	–
Polycyclic Aromatic Hydrocarbons (µg/L)	Non detected	Non detected	Non detected	Non detected	–
Oil & Grease[a] (mg/L)	1	1	<1	<1	–

4.1.6 Geology, Topography and Soils

4.1.6.1 Geomorphology/Topography

The geomorphology of the project area can be broadly divided into two sections: the alluvial plain on the eastern half; and the limestone karst terrain on the western half of the proposed highway.

Alluvial Plain

The flat alluvial plain (Figure 4.33) extends from the eastern boundary of the highway alignment in May Pen (K43+500) to Clarendon Park (K59+000) in the parish of Clarendon. Elevation ranges from 39 m (130ft) in the Decoy area to 69 m (230 ft) in May Pen. Sediments which emanate from the Cretaceous rock in the Central Inlier located north of the project site were brought down by the Rio Minho and deposited into the area of May Pen and its environs during the Quaternary Period.

The western section of the alluvial plain, also referred to as the St Jago Plains, is drained by many small streams and gullies that are fed by springs coming out of the limestone hills in the north.

Figure 4.33: A View of Part of the Alluvial Plain at the Intersection of the Highway Alignment and Road leading to Content Village (K48,800), Clarendon

Limestone Karst

The western half of the highway passes through an upland area consisting of limestone karst topography extending from Clarendon Park (K59+500) to Williamsfield (K71+770) at the end of the alignment. The type of karst landform is referred to as doline karst. Dolines are depressions or sinkholes normally circular or semi-circular in plan with diameter varying from a few metres to over 1km (Sweeting, 1958). The doline karst within the project area is interrupted by conical, semi-conical and elongated hills (Figure 4.34). The sinkholes and depressions are normally less than 50m deep, except where they are affected by geological faults. Elongated hills and depressions as well as narrow valleys are generally formed by geological faults that are present along the highway alignment. An example is in the Melrose Hill area where the geological faults have given rise to the formation of a deep elongated depression. Elevation in the hilly karst terrain rises from 75m (250 ft) near Clarendon Park to 369 m (1,220 ft) near the end of the highway alignment at Williamsfield.

Slopes are generally variable, usually moderate to steep, ranging from less than 18 degrees (34 percent slope) to over 45 degrees (100 percent slope).

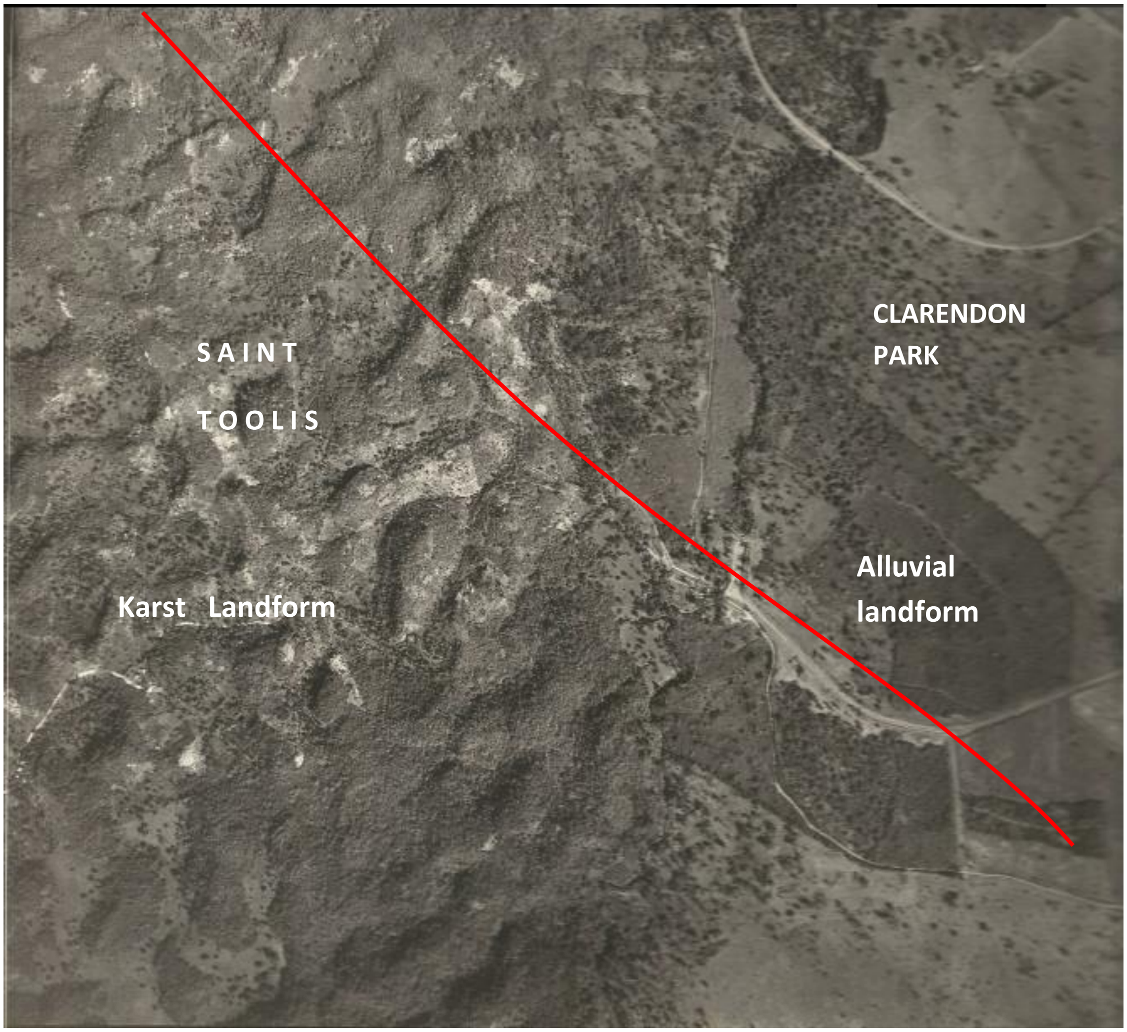


Figure 4.34: Aerial Photograph showing Alluvium and Karst Limestone in Project Area
The May Pen to Williamsfield Highway Alignment (shown in red) crosses this Section of the Project Site.
(Source: 1953–54 Aerial Photograph–Scale of 1:15,000).

4.1.6.2 Geology

The May Pen to Williamsfield Highway alignment passes through two main geological formations: surficial deposits consisting of alluvium; and the Miocene, Newport Limestone of the White Limestone Group (Figure 4.35).

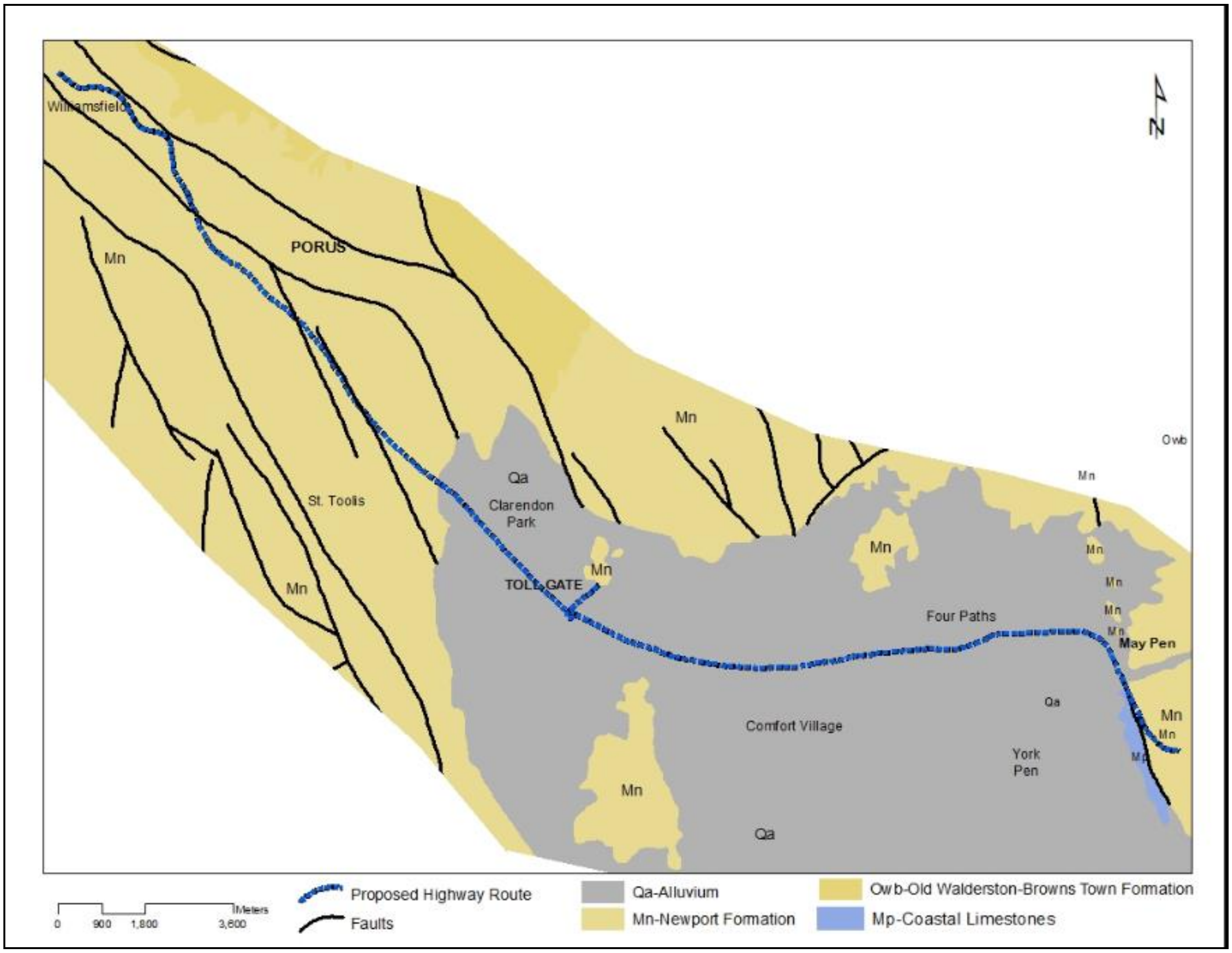


Figure 4.35: Geology Map of the Highway Alignment Project Area dominated by two Geological Formations

Surficial (Alluvial) Deposits (Qa)

Alluvial soil covers the project site from the May Pen Bridge (K43+500) at the starting point of the alignment to Clarendon Park (K59+000). The alluvium is derived from the deposition of sediments eroded from the Cretaceous rocks to the north as mentioned above, as well as from the weathering and erosion of limestone surrounding the area. The thickness of the alluvium is unknown, but it is thought to be variable throughout the site. The alluvium consists of a mixture of sand, silt and clay of varying proportions.

Newport Limestone (Mn)

The Newport Limestone forms the western section of the highway alignment, from Clarendon Park in Clarendon (K59+500) to Williamsfield (K71+770) in Manchester. This limestone is typically described as moderately, well bedded and compact limestone, usually poor in fossils, although fossil beds containing oysters and pectens can be found at certain localities (MGD Draft 1:50,000 Geology Map Series, Mandeville Sheet 11).

Site inspections conducted at a number of localities close to the highway alignment show that the limestone meets the type section description that defines the Newport Limestone, with some exceptions. In the St. Toolis Estate area, approximately 120m –150m south of the alignment (K59+500), an estimated 25m–30m high disused quarry face exposes limestone consisting of white-cream, soft to moderately soft, rubbly marls and chalky limestone (Figure 4.36.and Figure 4.37). Further to the north and behind the old quarry, the limestone varies from soft chalky limestone to buff coloured, moderately compact and bedded limestone. The limestone consists of thick beds of up to 3.5m.

Figure 4.36: Vertical Face of a disused Quarry at St. Toolis in Manchester (south of K59+500) consisting of soft Marls and chalky Limestone with thick Beds

Figure 4.37: Close-up View of the rubbly and marly Limestone in the disused Quarry

In the Reeves Wood area, 100m south west of (K62+500), the alignment crosses the side of an elongated hill consisting of moderately hard limestone which is partially recrystallized (Figure 4.38). Medium to very large boulders are strewn along the foot of the hill. Similarly, exposed road cut along the Melrose Bypass near the Williamsfield roundabout (K71+770) and at Trinity (K67+600) exposes limestone that can be described as moderately hard to hard partially recrystallized rock. At Trinity, the 10m–12m high road cut exposes limestone cavities filled with Terra Rosa soil (reddish brown clay) which has been partially been washed out or eroded by storm water (Figure 4.39).

Figure 4.38: Partly recrystallized Limestone Outcrop at the Foot of a Hill in Reeves Wood near to the Highway Alignment

Figure 4.39: 10m–12m High Road Cut with Cavities that were once filled with Terra Rossa Soil

Geology Structure

The major structural features are the geological faults which cross the highway alignment at three different locations and the Porus/Williamsfield Graben structure in the Melrose Hill area of Manchester. There are many NW–SE and NNW–SSE trending faults in the St. Toolis to Williamsfield area (hilly terrain of project site), that have an impact in the area. The alignment which passes through the highland of St. Toolis and Reeves Wood is closely aligned in the direction of the faults and this reduces the number of faults which crosses the alignment (Figure 4.40).

There are two, relatively small parallel faults in close proximity to each other which pass through the Reeves Wood and cross the alignment at different locations through the elongated hill (Figure 4.40 and Figure 4.41). Movement along these faults has possibly led to recrystallization within the fault zone and also the presence of loose, large limestone blocks observed on the hillside at Reeves Wood. These detached limestone blocks have the potential to be mobilized from the slope especially when there is disturbance caused by road construction activity.

At the Melrose Bypass, the major fault crosses the alignment at K67+500) and continues beyond the Williamsfield area. The Miocene Newport Limestone Formation represents the geology along the entire segment. Here the upper, recrystallized limestone is the more dominant horizon. From the highway route it appears that the section from Porus to the Melrose Bypass parallels closely one of the faults of the graben possibly crossing it or lying on top of it.

Figure 4.40: Geological Fault runs parallel to the Side of the Hill seen in the Background in Reeves Wood
The Highway Alignment passes along the Side of the Hill.

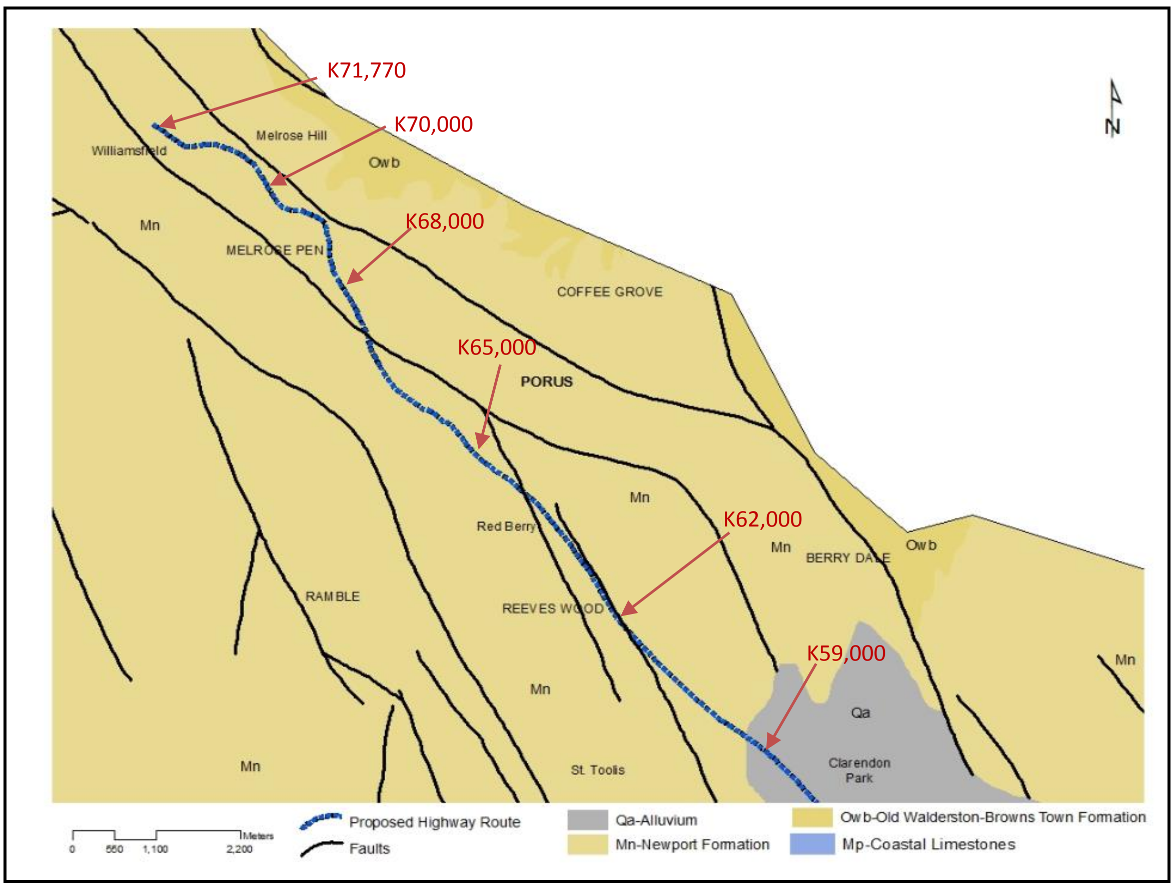


Figure 4.41: Geology Map of the Highway Alignment underlain by the Newport Limestone showing Locations where the Geological Faults cross the Highway Alignment

Soils

The Soil Classification Map developed by the Rural Physical Planning Unit of the Ministry of Agriculture shows that the soil type varies over 3 distinct areas: May Pen to Four Paths; Four Paths to Clarendon Park; and Clarendon Park to Williamsfield (Figure 4.42).

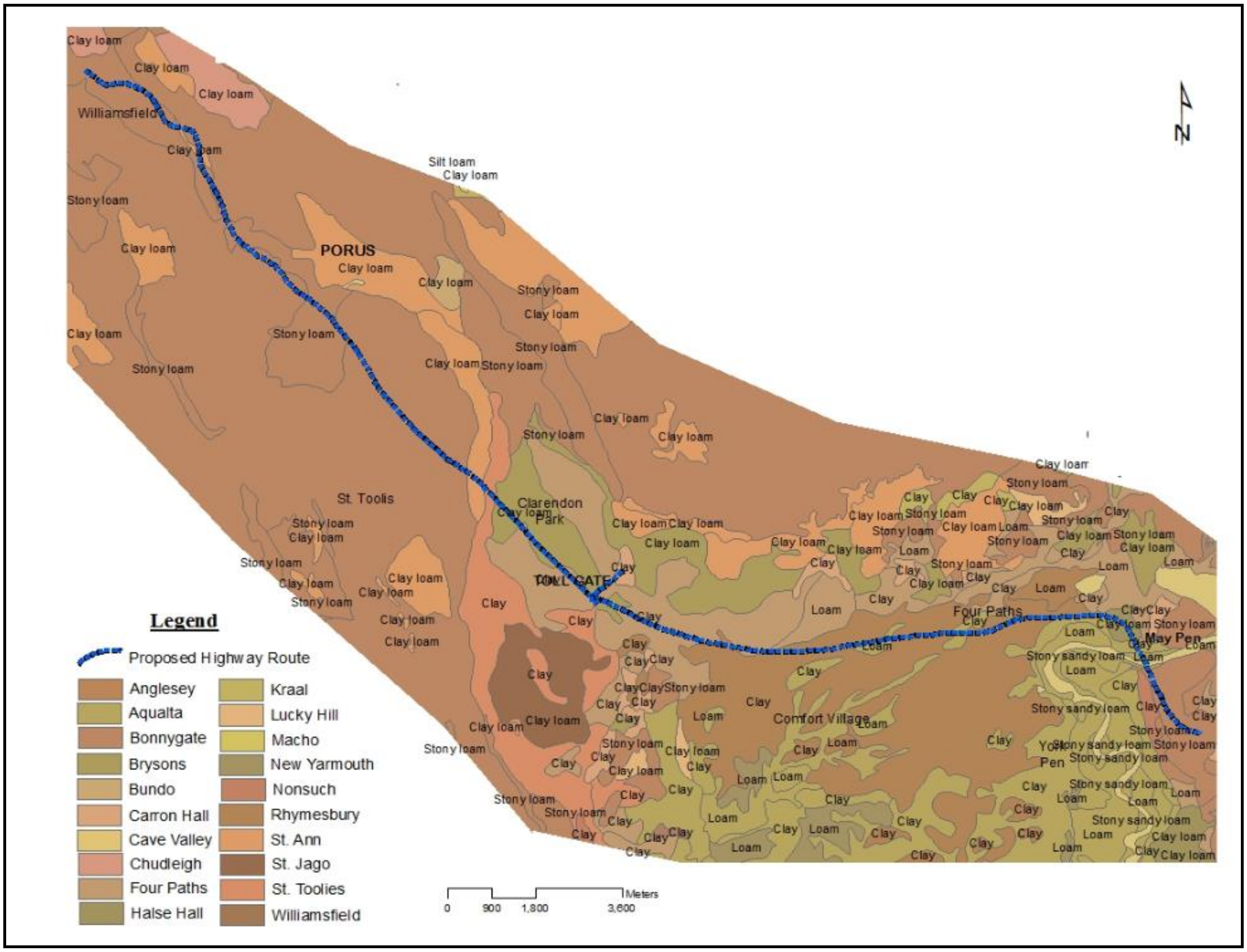


Figure 4.42: Soil Map of May Pen to Williamsfield Highway 2000 Project Area (Source: Rural Physical Planning, Ministry of Agriculture)

In the May Pen to Four paths area, the soil is classified as the Agualta Vale clay loam which generally has poor internal drainage. Continuing further west to Clarendon Park, the highway alignment passes through the Rhymesbury clay and Four Paths clay and the St. Ann Clay Loam. The soil type exhibits low to moderate erodibility and poor internal drainage.

The area between Clarendon Park and Williamsfield consists predominantly of the Bonny Gate Stony Loam. The Bonny Gate soil type is characterized by its sandy loam texture with high erodibility, very low moisture content and very rapid internal drainage.

With respect to engineering soil, the dominant soil in the alluvial section of the alignment is yellowish brown clay. Field work conducted in Flemmings Gully in the Toll Gate area (200m north of K55+300) shows evidence of firm to stiff yellowish brown clay exposed on the side of a 4m high gully bank. Within the karst limestone, reddish brown clay soil is found as the weathered product of the limestone, particularly in the Redberry and Porus areas in Manchester where the karst features are more subdued (Figure 4.43).

Figure 4.43: Terra Rossa Soil (reddish brown clay) exposed on a Road Cut in the Redberry Area of Manchester

Mineral Resources

Sand and Gravel: The Mineral Resource Map (Figure 4.44) developed by the Mines and Geology Division covers the eastern section of the alignment from May Pen in Clarendon to St. Toolis in Manchester. It shows that there are sand and gravel deposits on the eastern section of the highway alignment derived from the Rio Minho which drains on the eastern end of the alignment. The sand and gravel deposits are currently exploited for the building and construction industry by four licensed quarry operators who operate in the riverbed as well as outside of the riverbed (Figure 4.45).

It is expected that sand and gravel will be required as part of the asphaltic concrete mix for highway construction which implies that large quantities of the resource could be exploited economically for the project based on its availability in close proximity to the project site.

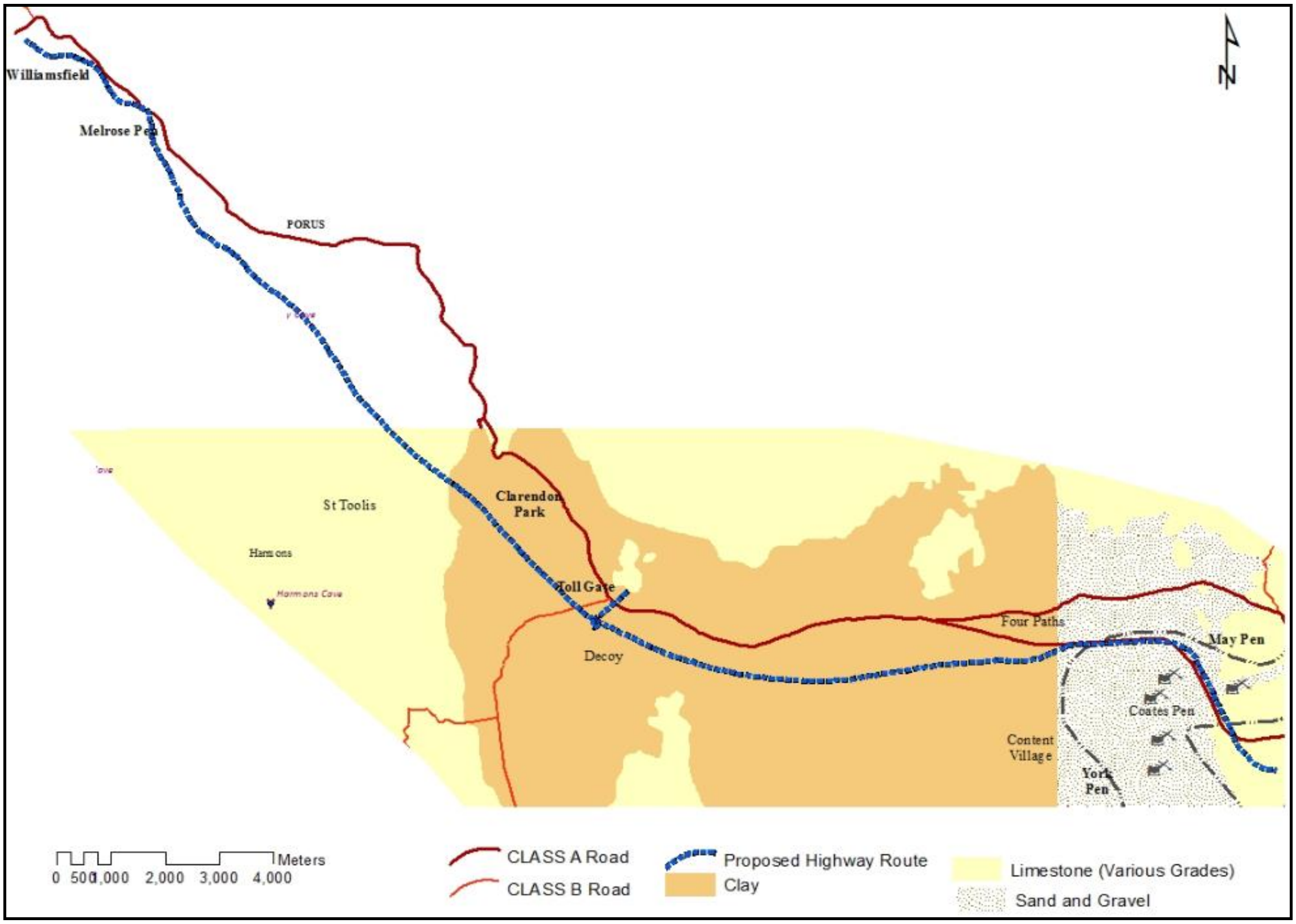


Figure 4.44: Mineral Resource Map (partially completed) for part of Western Clarendon and Eastern Manchester showing the Mineral Resources along the Highway Route

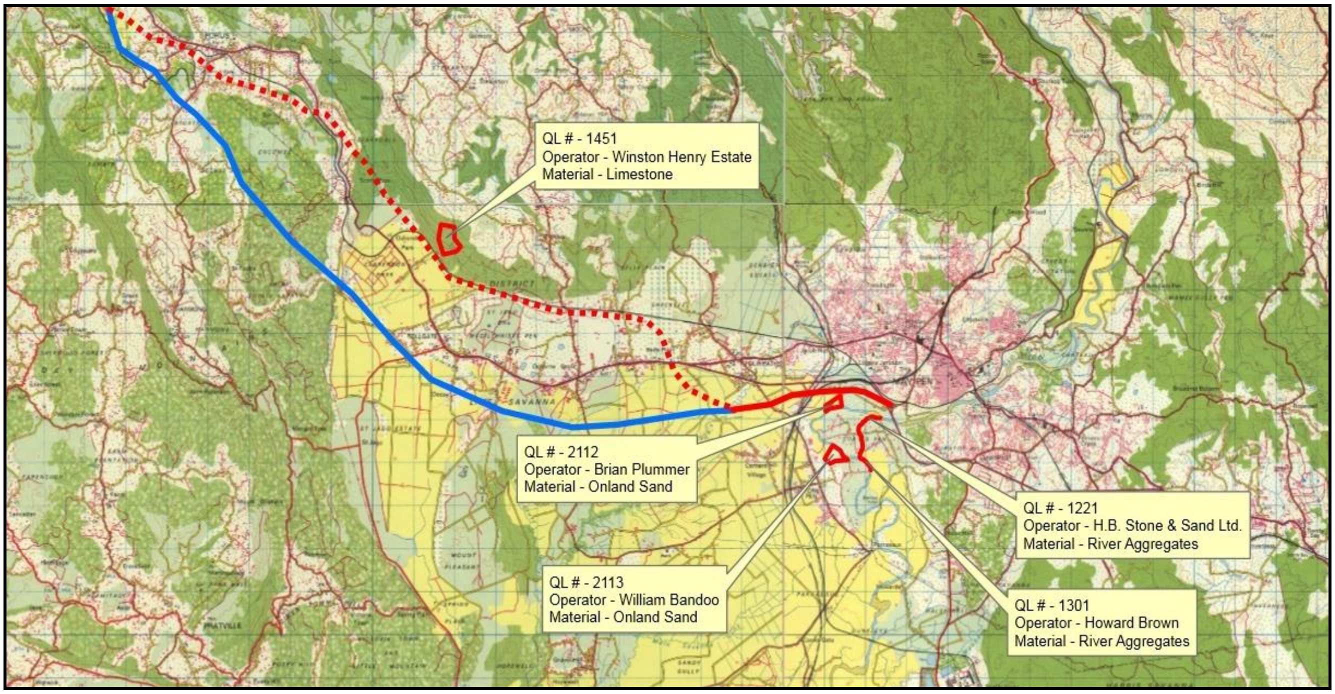


Figure 4.45: Licensed Quarries that are in close Proximity to the May Pen to Williamsfield Highway Alignment (Blue line). (Source: Mines and Geology Division)

Clay: Clay deposits lie west of Four Paths and extend further west into Clarendon Park. The thickness of the clay is uncertain, but available information suggests that the clays are thickest south of the project area (up to 160 m in Vernamfield). The clay is not currently exploited for economic purposes, but the area is considered good, arable land and has been used for agricultural production over the years**.**

Limestone: The Mineral Resource Map shows that the area west of Clarendon Park consists of various grades of limestone. This information can be extended to Williamsfield, since the alignment crosses the Newport Limestone to Wililliamsfield in Manchester at its end point. Additionally, a relatively large outcrop of limestone is also found in Ebony Park and the surrounding area which is close to the highway alignment. There is only one licensed quarry which is located to the north of Clarendon Park.

The purity of the Newport Limestone varies from 86 percent to 96 percent (Geddes, 1987) and is best utilized for low- to medium-grade application. The harder variety is used primarily as crushed aggregate in the construction industry, while the softer limestone (marls and chalks) are normally used as fill in the construction industry.

The need for construction aggregate as fill is paramount to the economic viability of the highway construction project. Copious amounts of construction fill will be required based in the depth of fill to be placed during construction of the highway, especially along the segment between May Pen (K43,500) and Clarendon Park (K59,000). The closest deposit to the alignment is to be found in the Ebony Park area (1km south of K54,500). This limestone deposit can be exploited as fill due to its close proximity to the project site; however, some physical testing will be required to determine the quality of the material for such purposes.

Limestone aggregate as fill will also be used for highway construction on the western segment of the project – from Clarendon Park to Williamsfield – where the highway passes through limestone terrain. Material excavated for the roadway will be used for the placement of fill along this section. Based on volume estimates for cut and fill, there will be a budget surplus for the highway which implies that most of the excess material will be used as fill along the May Pen to Clarendon Park segment.

Bauxite Deposits

Information provided by the Jamaica Bauxite Institute (JBI) shows that the highway alignment passes through a number of bauxite deposits in Redberry, Reeves Wood and St. Toolis (Figure 4.46). Bauxite is Jamaica's third highest foreign exchange earner and it is therefore a very important mineral resource for the country. This bauxite is currently exploited by Jamalco for the making alumina, an intermediary product of aluminum. If the alignment remains in its current path, then the bauxite deposits will be sterilized by the construction of the highway. The JBI has indicated that after exiting Clarendon Park, the highway alignment passes through the mining lease operated by Jamalco, and that they reserve the right to have the bauxite deposits mined out where sterilization is unavoidable.

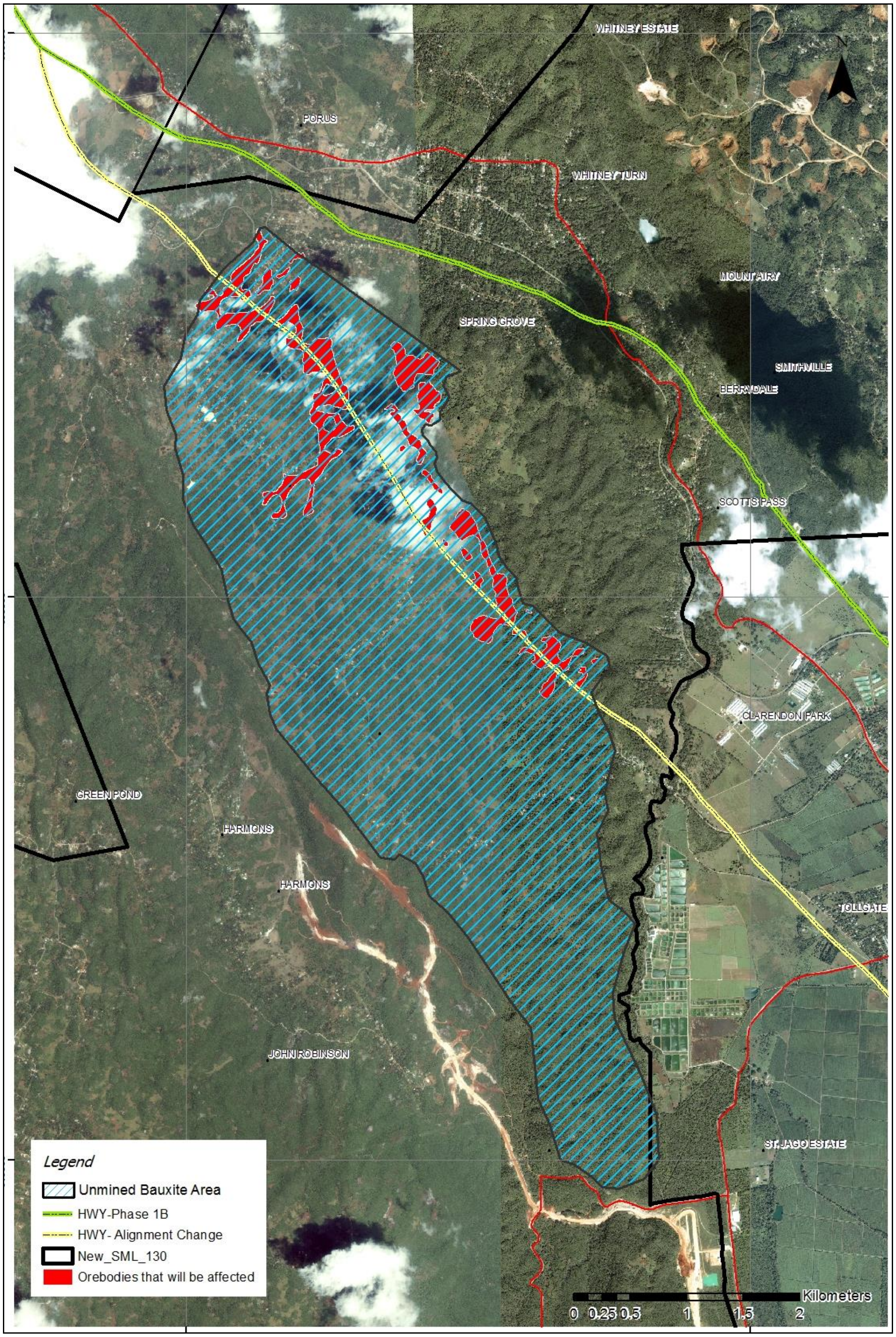


Figure 4.46: May Pen to Williamsfield Highway Alignment passes through Bauxite Reserves in St. Toolis, Reeves Wood and Redberry Areas of Manchester (Source: Jamaica Bauxite Institute)

4.1.7 Natural Hazard and Geotechnical Classification

4.1.7.1 Geotechnical Classification

Geotechnical data for the project area is inadequate and limited to a few sites which were identified in the '*Highway 2000 Geotechnical Study Report'* prepared by Dessau-Soprin. Geotechnical information for the alluvium along the highway is essentially non-existent. Data availability is mainly confined to the Porus to Williamsfield section on the Melrose Bypass based on a qualitative and quantitative description of outcrops along the alignment. The methodology used is based an engineering geology description of the rock mass as well as measurements of the structural planes (orientation of rock joints and bedding planes) along the road cut. Additionally, shallow boreholes were conducted in the Porus area to a maximum depth of 1.8 m using drilling methods for the collection of disturbed samples.

The rock mass along the Melrose bypass is described as beige, dolomitized, fossiliferous limestone with some dissolution cavities and hardness ranging from 3.5–4 based on Mohs scale of hardness. The orientation of structural planes etc. and thickness of rock discontinuities are is shown in Table 4.6. Borehole data for the Porus area were limited to a description of the weathered material above the limestone which is described as red clay with some silt and traces of sand.

Table 4.6: Engineering Description of Limestone Rock Mass on Melrose Bypass Road (Source: Highway 2000 Geotechnical Study Report: Dessau-Soprin, 2000)

Location	Length (m)	Height (m)	Az/ Dip	Structural Plane		Description	Mohs Hardness
				Az/Dip	s (m)		
Williamsfield	50	3.5	250 80	60/88 230/10 20/83 10/45	0.5 0.6 0.3 0.3	Beige fossiliferous limestone with some dissolution cavities	4
Porus/ Melrose Bypass	500	15	130 80	140/76 55/85 270/22	<0.1 <0.1 <0.1	Beige dolomitized fossiliferous limestone with some dissolution cavities	4
Porus/ Melrose Bypass	120	6	80 75	150/81 10/15 240/85	<0.1 <0.1 <0.1	White fossiliferous limestone	3.5

The Newport Limestone which is grouped with similar limestone rocks in Jamaica has been classified (Bryce and Ohara, 1982) into a number of geotechnical parameters. The information is not meant to be site specific, but was prepared to provide basic information for planning and development purposes. A geotechnical classification of the Newport limestone (with associated limestone rocks) is shown in Table 4.7.

Table 4.7: Geotechnical Classification of the Newport Limestone (Source: Bryce and Ohara – Geological Survey Division)

Newport Limestone Description	Method Excavation	Permeability	Slope Stability	Presumed Bearing Capacity	Construction Problems
Rocks are variable, but generally hard and competent: original structures, fossils, etc. are often absent due to recrystallization and dolomitization; strata are generally thickly to very thickly bedded or massive; rubbly facies should be anticipated in association with fault zones	Primarily blast excavation	Primary: low Secondary: Very High	Design slope 1:2 if no information available Soils: high cohesion	Variable: 1000-4000 KN/m² for rock Soil: 40–500 KN/m²	Flood risk in depressions Collapse of underground cavities Landslides along fault zones

4.1.7.2 Geotechnical Considerations (Foundation and Earth Works) for highway Construction

As part of the highway construction, the alignment passes over a total of 53 crossings such as rivers, gullies, canals, minor roads, haul roads and railway lines. The major structural elements for the crossings include pre-stressed girder bridges for the rivers, railway lines, inter-changes, major roads. The minor gullies, canals and minor roads are proposed to be crossed using plate and box underpasses. The bridges and their locations are as follows:

- Rio Minho Bridge: at K44+100
- Railway Bridge (May Pen – Williamsfield) at K46+400
- Overpass Bridge（May Pen – Williamsfield）at K47+400
- Local River Bridge（May Pen – Williamsfield） at K48+550
- Interchange Bridge（May Pen – Williamsfield） at K56+000.

The type of foundations for the bridges is cast-in bored piers. Site specific geotechnical investigation will be a necessary requirement for the construction of the foundation of bridge structures and underpasses.

Additionally, the highway route will have extensive cut and fill along its length. Fill for the highway is proposed to vary from 1m (shallow) to 14m (very deep) with an estimated average of 6m between May Pen and Clarendon Park. To maintain the 6 percent gradient for highway construction, the deepest fill of 11m–14m will be placed in the Clarendon Park area (K59+300–K59+550) where it begins to ascend the steep hills of St. Toolis Estate (Figure 4.47 and Figure 4.48). At Decoy, (K54+500–K55+000), deep fill of up to 11m is to be placed on the alluvial soil. It is assumed that the thickness of fill is partly based on the geotechnical considerations relating to the possibility of ground deformation in the underlying clay soils in the alluvium. Some excavation of the clay will be done using excavators and bulldozers in layers and then the fill will be dumped, rolled and compacted.

In areas of deep fill, high embankment slopes will be created, therefore, the stability of the embankment slopes will need to be analyzed in those areas.

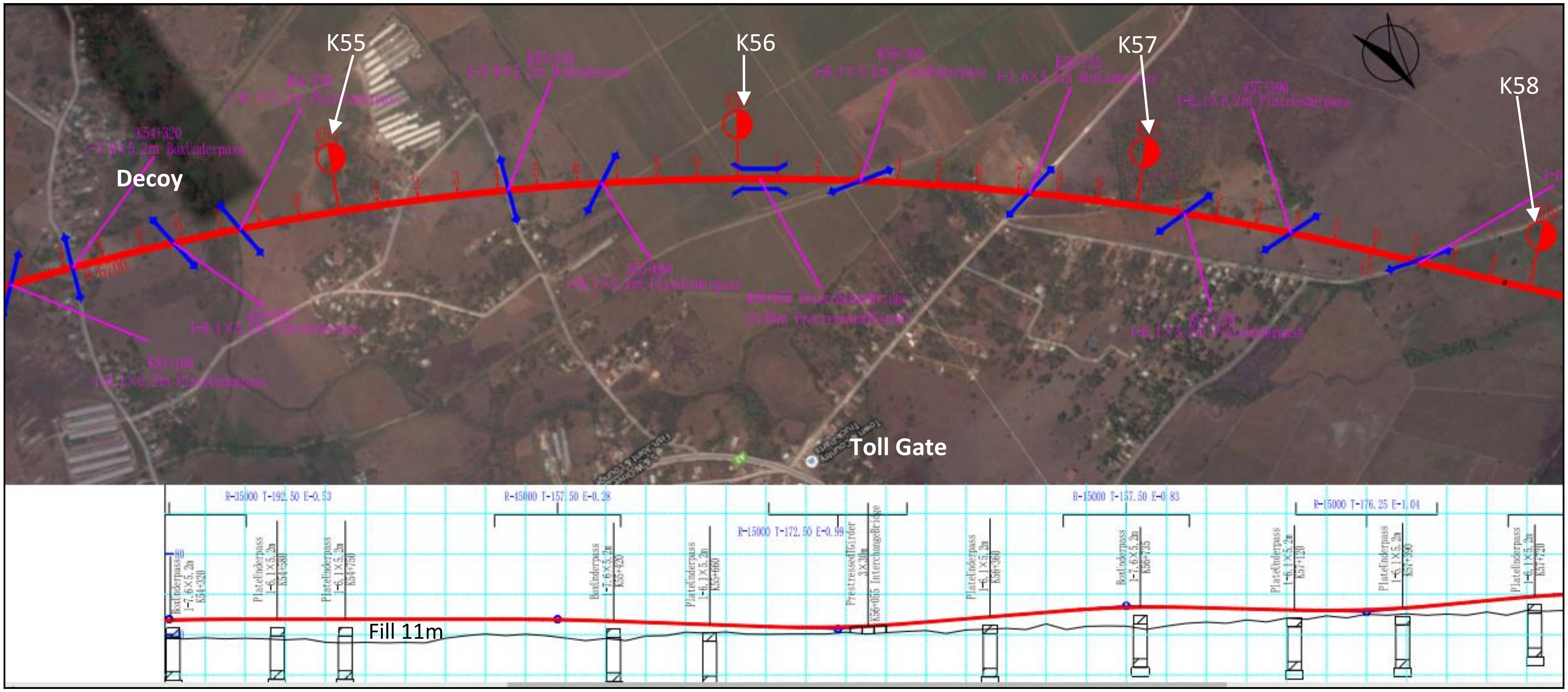


Figure 4.47: Proposed Road Gradient Profile which shows deep Fill of up to 11m to be placed as Road Fill for Highway Construction in the Decoy Area of Clarendon

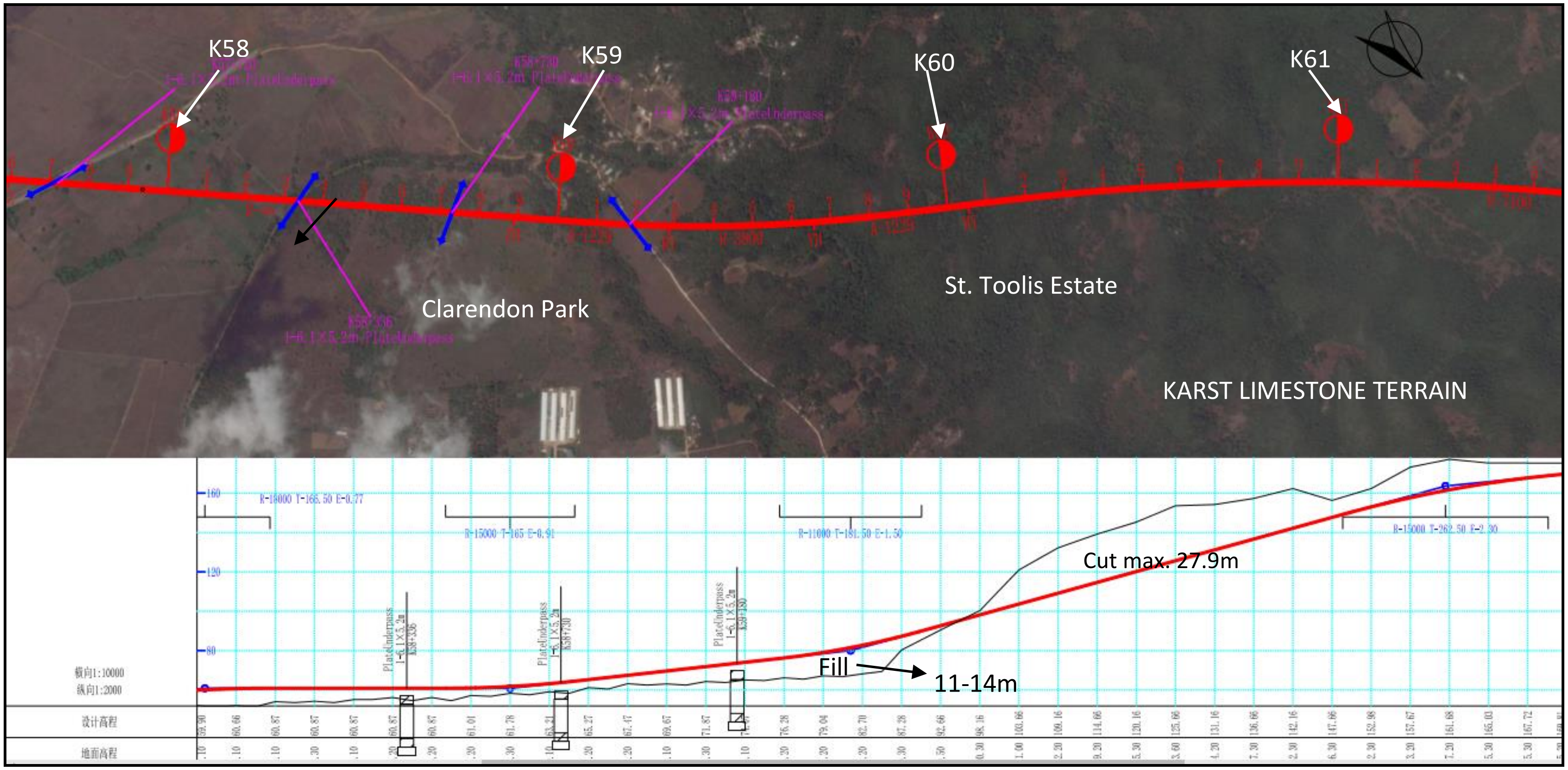


Figure 4.48: Proposed Road Gradient Profile for Highway Alignment as it enters the hilly Limestone Terrain of St. Toolis Deep Cuts and extensive Fill (earth works) are to be conducted for Construction of the May Pen to Williamsfield Highway.

Excavation Cuts and Fills (Earthworks) in Limestone Karst Terrain

Preliminary road elevation profiles for the highway construction indicates that deep cuts are to be excavated into the limestone hills around the St. Toolis area (near the border of Clarendon and Manchester) and Melrose Bypass in Manchester. In St. Toolis, deep cuts of ranging from 15m –27.9m over a distance of 1.1 Km (K59+900–K61+000) and 13m–21m (K62+800–K62+900) are to be excavated in the karst limestone (refer to Figure 5.4.1b). These cuts will create very high slopes which could create stability problems if not adequately engineered. This area is poorly accessed because of difficult topography. Field evidence at a disused quarry 150 km south of location K55+500 and in the surrounding areas shows that the limestone varies from soft chalky limestone and rubbly marls to medium strong limestone. The exposed face of the quarry has remained relatively stable on a 25m–30m high vertical slope.

Excavation for road construction (14m–21m depth) will be made in the Melrose Hill area (K69+500–K69+700) over a distance of 200m. The limestone exposed on the bypass road (up to 10m high) is considered to be medium strong to strong, partially recrystallized limestone and the road cuts have remained stable for long periods.

Construction over Depressions/Sinkholes

The highway alignment will also pass through a number of limestone depressions which will be filled in order to facilitate construction of the highway. Where sinkholes can be avoided, this will become a priority. The developer has devised a number of engineering methods to address the issue of construction in depressions and sinkholes based on proximity of the alignment to these features and taking into consideration their hydrogeological characteristics and functions (Figure 4.92).

Design Considerations

The following design considerations will be followed during the design and construction of the Highway in areas where sinkholes are present:

- <u>Avoidance:</u> Determine if there are any feasible alternatives that would prevent construction in the area of the sinkhole. Where the sinkhole is the natural outfall for the stormwater runoff from the roadway area, determine if the stormwater runoff can be diverted away from the sinkhole to an adequate surface water channel.

- <u>Minimization of Impacts from Direct Discharges:</u> If avoidance is not possible, drainage outfalls from the highway should include natural buffer zones between the outlet of the highway drainage structure and the sinkhole in order to provide for a natural filtering process and to improve runoff water quality by filtration and absorption of contaminants (Figure 5.20).

If stormwater runoff from the highway project is directed to the sinkhole, the drainage design for the project should reflect how the sinkhole is anticipated to function after completion of construction activities.

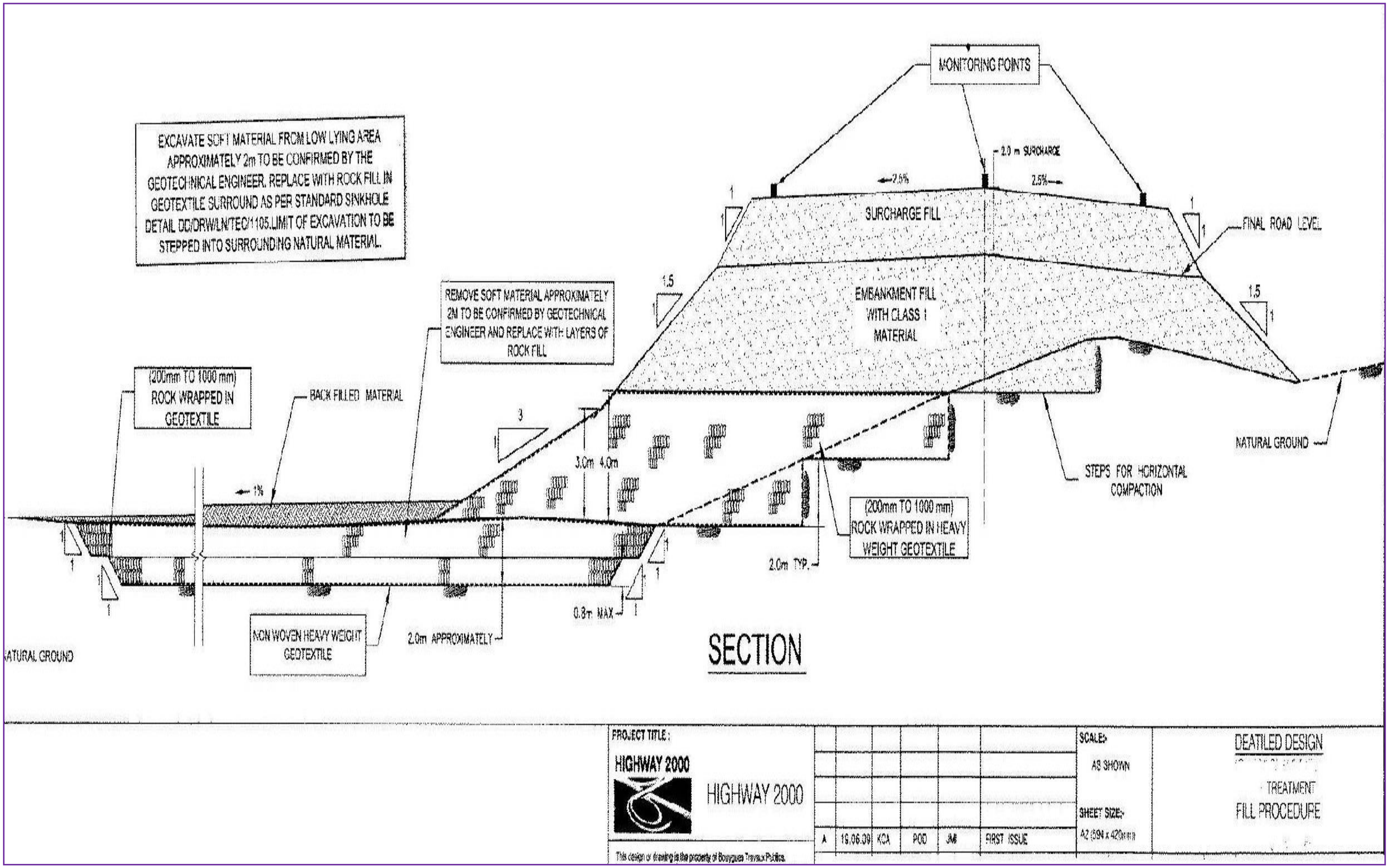


Figure 4.49: Treatment & Fill Procedure (Source: NROCC)

4.1.7.3 Landslide Hazard and Slope Stability

Landslide susceptibility for the project site is not available, however, a Landslide Hazard Zonation Map for South Manchester consisting of the Newport Limestone was prepared as part of Halcrow's South Coast Sustainable Development Study – *Technical Report 4*. The map shows that South Manchester lies within the very low to low landslide hazard zone (Figure 4.50).

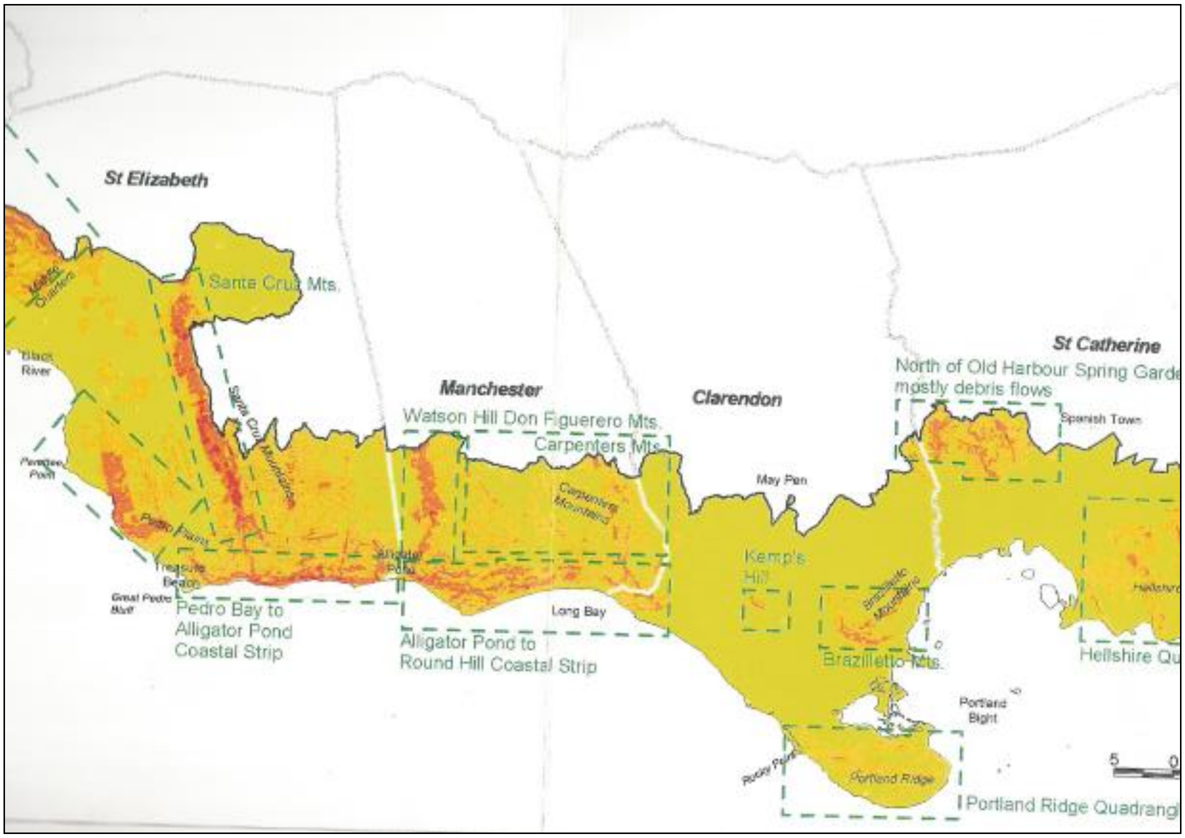


Figure 4.50: Landslide Hazard Zonation Map of South Coast of Jamaica, including South Manchester. (Source: Jamaica South Coast Sustainable Development Study- Technical Report 4)

Aerial photographic interpretation for identifying landslides was conducted along the May Pen to Williamsfield Highway alignment using black and white panchromatic photograph at a scale of 1:15,000. There were two areas identified within the project area interpreted as landslides (Figure 4.92). The first and smaller area is a shallow landslide located in a tributary gully of the Milk River in the hills of St. Toolis Estate where the limestone rises sharply from the alluvial plain overlooking Clarendon Park. It is approximately 50m–60m north of the alignment at K55+800 and measures about 60m–80m along the length of the slope on the bank of the gully.

The second and larger area interpreted as landslide is located approximately 600m north of K64+000 in Dawkins–Porus between Redberry and Porus. This area is estimated to be 500m in length and 240m–250m in width and forms a topographic anomaly between 2 geological faults. These areas interpreted as slope failures were not confirmed in the field due to problems of access. The larger landslide area is some distance outside of the highway alignment and not considered a threat to the development. However, if there are considerations to shift the alignment to the north east, then the location of this area should be carefully noted and avoided.

Figure 4.51: Google Image showing landslide locations near Porus and St Toolis in Manchester interpreted from Aerial photographs

4.1.7.4 Rockfall

One of the two parallel geological faults passes through the Reeves Wood area (K62+500). At the foot of the hill is to be found limestone boulders of varying sizes scattered within the area. A very large boulder weighing hundreds of tons was located at the side of a house (Figure 4.52). The highway alignment passes through the side of the hill and during excavation and construction, there will be an increase in rockfall susceptibility.

Figure 4.52: Very large Limestone Boulder on a residential Property in Reeves Wood, Manchester

Similarly, a major geological fault crosses the highway alignment along the existing Melrose Bypass (K67+500) resulting in the rocks being extensively fractured. As part of the proposal, further widening is expected to be done at that section of the road to upgrade the Melrose Bypass which will be incorporated into the new highway. The potential for rockfalls is moderate during excavation work and following and road construction, however, mitigation measures for reducing rockfalls and slides will reduce the impact of slope failures along the proposed highway.

In general terms, the limestone is shown to be stable with respect to slope movement as seen from the high excavation cuts in the Melrose Bypass as well as the disused quarry face in the St. Toolis area where the vertical rock face extends to over 25m high.

4.1.7.5 Blasting

Sections of the highway alignment identified for blast excavation include St. Toolis, Reeves Wood, Porus and the Melrose Hill in the karst limestone terrain. St. Toolis and Reeves Wood, and to a lesser extent the Melrose Bypass, will have deep excavations (13m–27.9m) cut into the hills to accommodate the 6 percent gradient allowed for construction of the highway. The principal method for excavating the limestone is by blasting due to the relative hardness of the rock mass. A review of the locations where blasting will be conducted shows that the areas are generally unpopulated or poorly populated which minimizes the problems usually caused by blast vibrations on residential communities. The area of the alignment which will require the most extensive blasting is in St. Toolis (depth of 15m 27.9m over a distance of 1.1 km) which has thick woodland and an absence of habitation. There is an existing residential population in the Porus community which the alignment crosses, however, most of the construction activity will be roadbed filling although small sections have been identified where blasting will be done.

4.1.7.6 Earthquake Hazard

Seismic data from the Earthquake Unit in Jamaica indicates that the nearest source area to the May Pen to Williamsfield Highway alignment for generating damaging earthquakes is the Rio Minho–Crawle River Fault. This fault passes approximately 25km–30 km north of the project area and is associated with the Gonave microplate, which includes the Plantain Garden–Enriquillo Fault Zone (Figure 4.53). The Kingston Seismic Hazard Assessment Study (1999) indicates that the slip rate of the Rio Minho–Crawle River Fault is approximately 5mm/year.

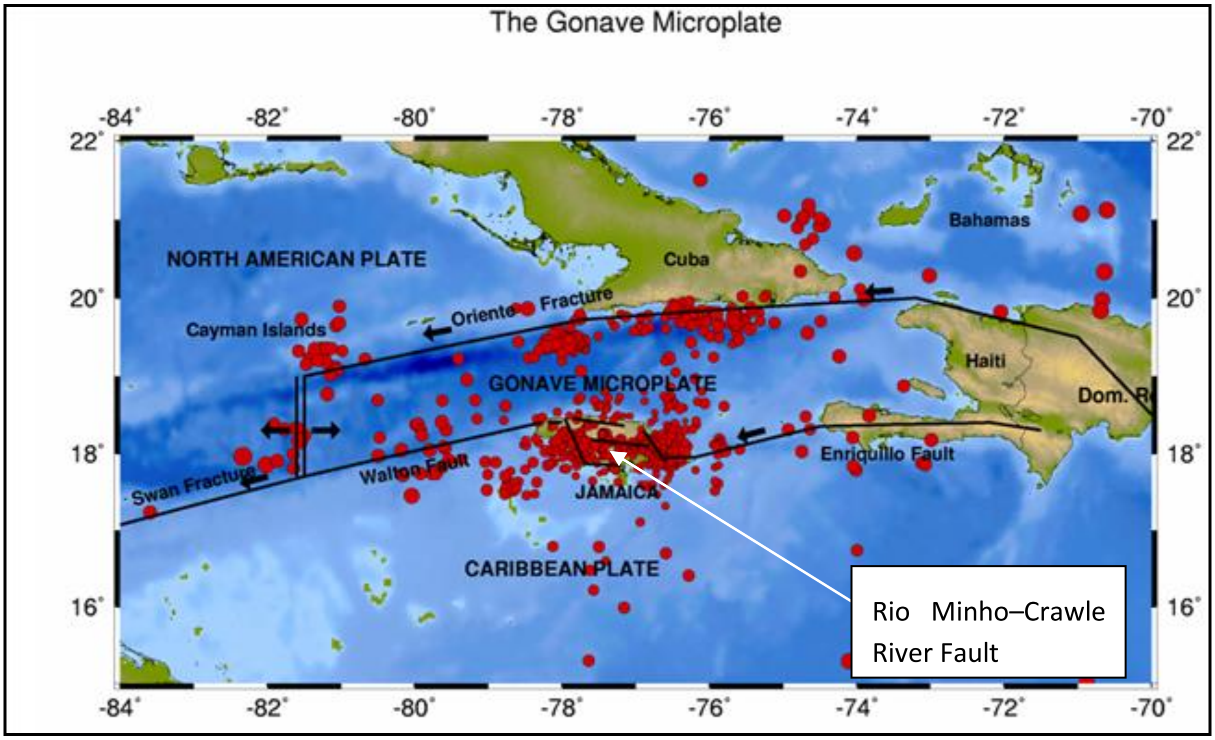


Figure 4.53: The Gonave Microplate which shows Strike-slip Faults across Jamaica including the Rio Minho–Crawle River Fault (Source: Earthquake Unit, UWI)

The most recent damaging earthquake associated with the Rio Minho–Crawle River Fault is the Aenon Town, Central Jamaica Earthquake on June 12, 2005, with a magnitude of 5.1. This earthquake caused some structural damage to a number of houses in the Aenon Town and Alston Area in Northern Clarendon and also caused rockfalls in Frazier, SW St. Ann.

Figure 4.54 provides data on the number of earthquake events for different localities in Jamaica for the 3-year period between the years 2010–2012. The Rio Minho–Crawle River Fault shows 14 earthquake events in 2012 and is only surpassed by the Blue Mountain region for that year.

Shepherd and Aspinall (1999) conducted seismic studies for Jamaica and placed the project site and surrounding areas as having a peak ground acceleration of 17–19 percent of gravity with a 10 percent probability of exceedance in 50 years (Figure 4.55). The earthquake source areas for this study were based on offshore sources capable of generating large earthquakes.

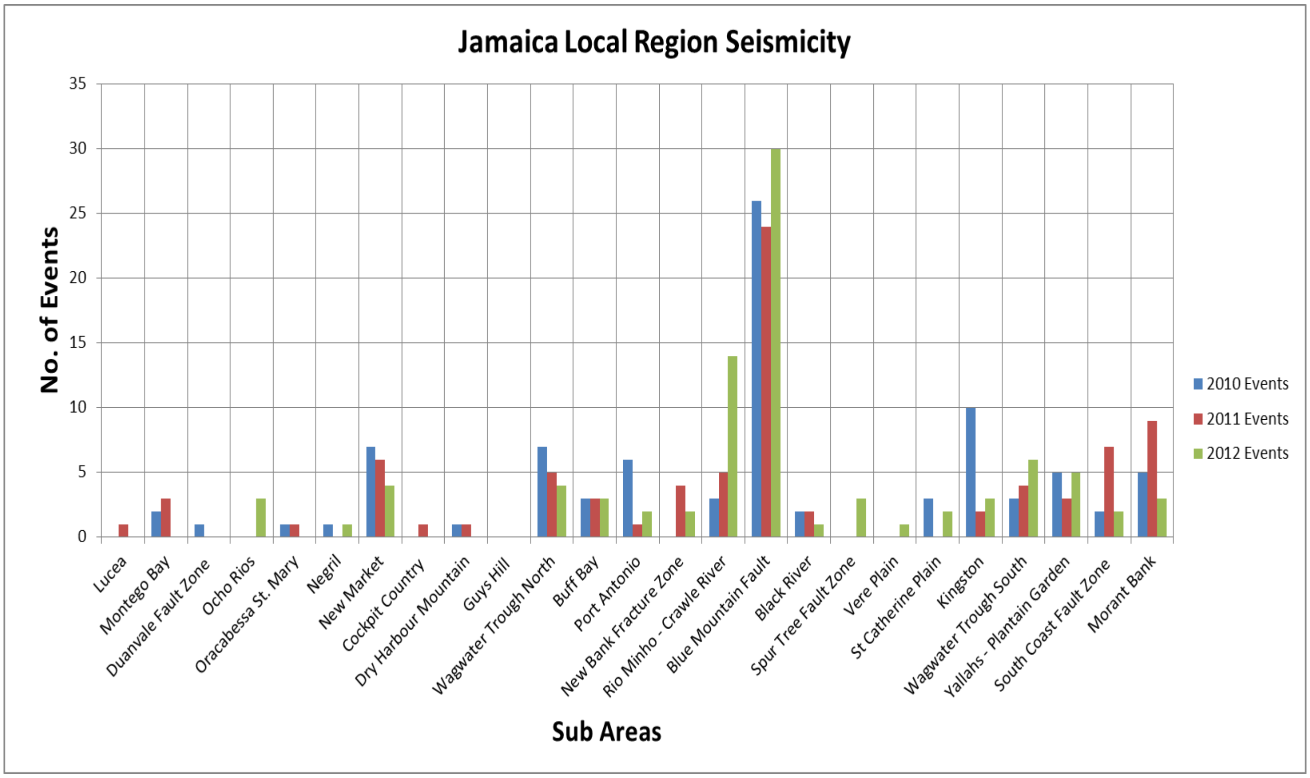
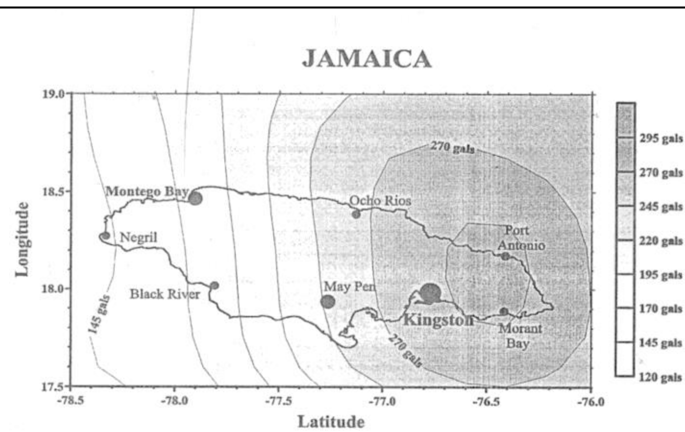


Figure 4.54: Graph showing the Number of Earthquake Events over a 3-year Period for Subregions in Jamaica (Source: UNDP)



Horizontal Ground Acceleration Map with a 10% Probability of Exceedence in 50 years (Shepherd and Aspinall 1999)

Figure 4.55: Horizontal Ground Acceleration Map for Jamaica

Spectral Site Response

Response spectra are typically used to illustrate the characteristics of an earthquake and are usually plots of ground acceleration against a range of natural periods measured in seconds. With respect to application, response spectra are normally used as input data in dynamic analysis of elastic systems such as building structures and critical facilities.

The International Building Code (IBC) adopted for Jamaica recommends that the Peak Spectral Site Response Acceleration for the project site and surrounding areas be 40 % of gravity for 0.2s short-period waves and 20% of gravity for 1.0s long-period waves with a 2% probability (2,475 yr. Return Period) of exceedance in a 50-year period (Figure 4.56).

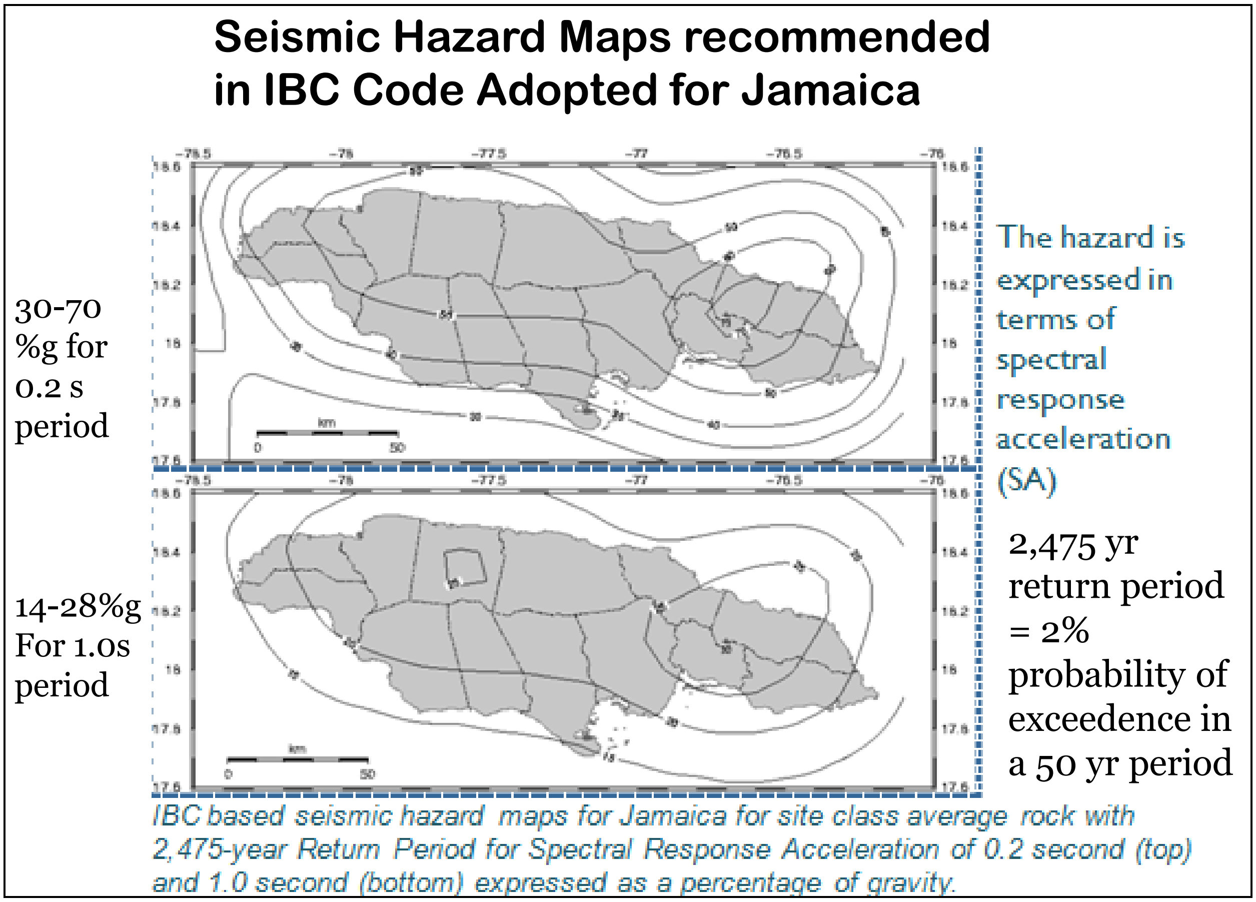


Figure 4.56: Site Spectral Response Map for 0.2s short-period and 1.0s long-period Waves (Source: Earthquake Unit, UWI)

4.1.7.7 Erosion & Sediment Control

Effective erosion control and sedimentation prevention begin in the planning and location stages of a highway route. Each highway route alternative has a base erosion potential which varies from route to route. These alternative routes can also present a range of sedimentation problems and controls. Unless damage from erosion and sedimentation is considered in selecting a route location, project implementation may result in unreasonable economic and environmental costs that may have been avoided during the planning process.

The best management practices to be incorporated into planning and project development are the management practices that will lead to the selection of the ***Least Environmentally Damaging Practicable Alternative*** (LEDPA) that satisfies the purpose and need of the project. Although this project concentrates on best management practices for erosion control and sedimentation prevention, the selection of the LEDPA must be based on an evaluation of all the project's impacts on both the natural and the manmade environment, including its socioeconomic impacts. Once the least environmentally damaging practicable alternative has been identified, the incorporation into the design of effective permanent runoff management and erosion control measures (and other appropriate mitigation measures) can further significantly reduce the long-range economic and environmental costs of the project.

Processes To Be Implemented During Planning and Early Design Phase

- Identify the need and purpose for the construction project;
- Identify erosion-sensitive areas for the alternatives under consideration;
- Identify sediment-sensitive areas for each alternative;
- Identify sensitive water-dependent resources that may be affected by project-induced changes in hydrology or water contamination;
- Identify sources of potential contamination;
- Identify project location alternatives that would address the need of the project while minimizing the project's adverse impacts on sensitive resources identified in previous stages.

These alternatives should:

- Avoid conversion, to the extent practicable, of areas that are particularly susceptible to erosion and sediment loss;
- Preserve areas that provide important water quality benefits and/or are necessary to maintain riparian and aquatic biota;
- Protect, to the extent practicable, the natural integrity of water bodies and natural drainage systems;
- Select the LEDPA considering all the project's environmental, social and economic impacts.

4.1.8 Hydrogeology

The elevation changes over the length of the highway ranges between 40m at the eastern end to just under 400m at the western end. From Km44+000 to Km57+000, the average ground elevation is about 40m above sea level. Beyond Km57+000, the elevation begins to increase to above 400m as the mountains are encountered just west of the Milk River.

The hydrogeology of the site comprises two distinct aquifer groups: the Limestone Aquifer to the west; and the Alluvium Aquifer to the east. The latter occupies the alluvial plains from Km44+000 to

Km56+000. Figure 4.57 shows the aerial extent of the aquifer groups across the site, both classifications align with the dominant geology across the highway corridor – White Limestone in the hills and Alluvium within the plains. Groundwater depth is estimated between 5 – 20m below ground level with principal flow direct to the south.

Surface drainage is dominated by the Milk River watershed in the west and the Rio Minho and its tributaries watershed in the east. Flow is predominantly to the south with fault-controlled flows in the limestone hills. No springs are recorded within the highway corridor; however, several temporal springs were reported during the June 2002 torrential rains particularly between 130 – 180m elevation. These springs lasted for just over 3 months before they dried up.

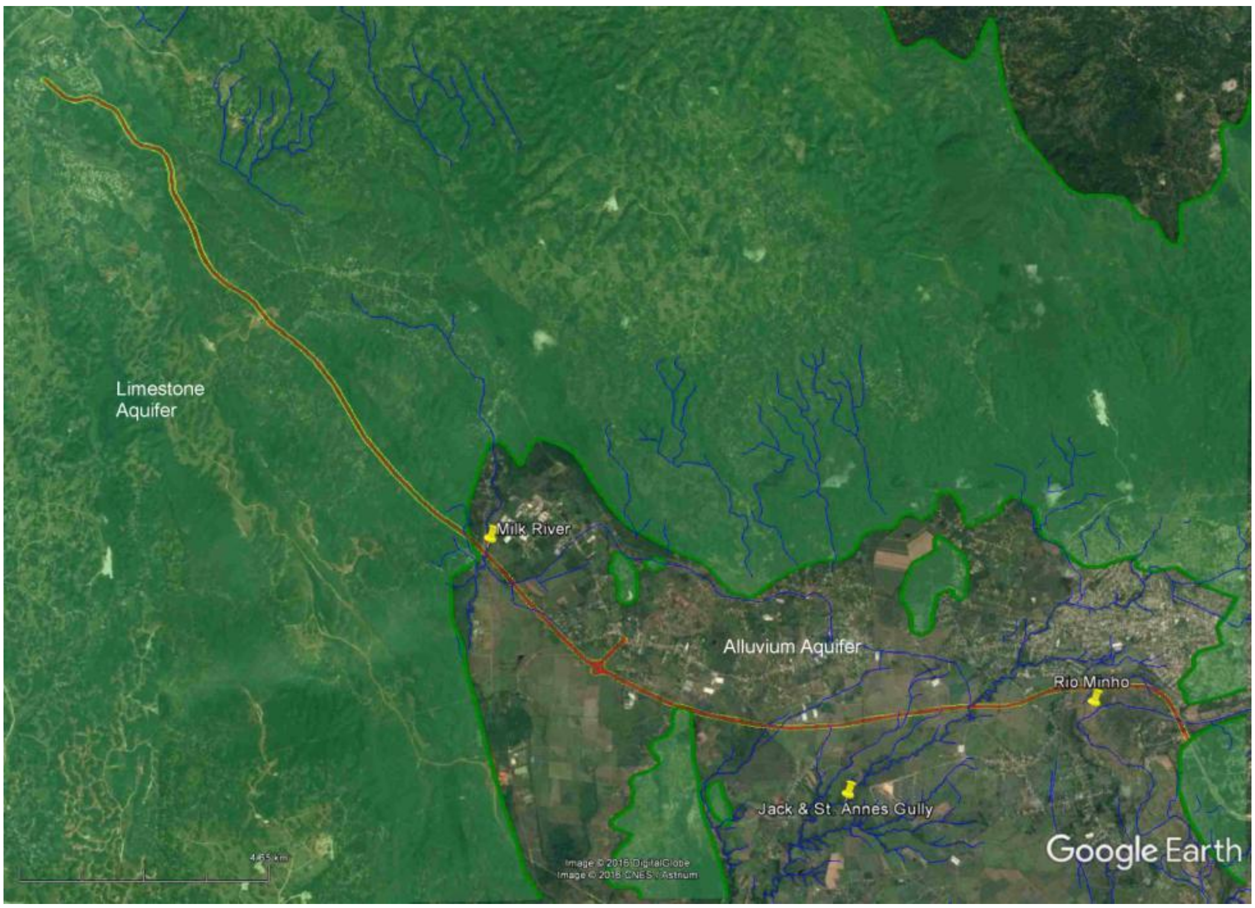


Figure 4.57: Hydrostratigraphy (Limestone Aquifer – shaded green; Alluvium Aquifer - unshaded) and Surface Drainage (blue polylines) along the Highway Corridor

4.1.8.1 Groundwater and Surface Water Resources

The hydrogeological and hydrological characteristics along the corridor are reviewed in order to identify and recognize the possible practical decisions required during the construction and operational phases of the proposed highway.

Due to the presence of the limestone and alluvial aquifers, groundwater resources are abundant across the corridor. Over 10 groundwater wells are located within1km buffer of the site. With two wells being within 100m of the corridor, St. Toolis No.3 and Fattening Pasture, the former will be directly impacted by the highway corridor. St. Toolis No.3 is owned by the National Irrigation Commission (NIC) and Fattening Pasture by the National Water Commission (NWC). Table 4.8 below lists the five (5) wells within 150m of the corridor centreline.

Table 4.8: Wells within 150m of Corridor Centreline

WELL ID	Distance from Centreline	Owner	Comments
St. Toolis No.3	25m north of Km59+700	NIC	Water Depth: 325ft
Fattening Pasture	72m east of Km44+500	NWC	Water Depth:350ft
Content Well	114m south of Km48+450	NIC	
St. Toolis No. 1 & 2	145m south of Km59+200	NIC	
Milk River No.2	146m south of Km58+730	NIC	Water Depth: 325ft

There are several major tributaries like the St. Anne's Gully that also cross the highway corridor.

Table 4.9 below summarizes the major and minor crossing anticipated by the project.

Table 4.9: Major and Minor Crossings Proposed for H2K Realignment

Approx. Chainage	Water Crossing	Structure	Type of Crossing
Km44+100	Rio Minho	Bridge Span	Major
Km46+250	Irrigation canal/Tributary	Culvert	Minor
Km46+720	1st order tributary, St. Anne's Gully	Culvert	Minor
Km48+050	1st order tributary, St. Anne's Gully	Culvert	Minor
Km48+560	St. Anne's Gully	Bridge Span	Major
Km49+850	2nd order tributary, St. Anne's Gully	Culvert	Minor
Km50+000	1st order tributary, St. Anne's Gully	Culvert	Minor
Km50+700	Irrigation canal or drainage	Culvert	Minor
Km51+350	1st order tributary, St. Anne's Gully	Culvert	Minor
Km52+150	1st order tributary, St. Anne's Gully	Culvert	Minor
Km52+300	Rhymesbury Gully	Culvert	Minor
Km52+640	1st order tributary, Rhymesbury Gully	Culvert	Minor
Km52+830	1st order tributary, Rhymesbury Gully	Culvert	Minor

Approx. Chainage	Water Crossing	Structure	Type of Crossing
Km53+030	1st order tributary, St. Anne's Gully	Culvert	Minor
Km54+160	Irrigation canal	Culvert	Minor
Km54+400	Irrigation Canal	Culvert	Minor
Km54+750	Flemmings Gully	Culvert	Minor
Tollgate Exit	Flemmings Gully	Culvert	Minor
Km56+360	Irrigation Canal	Culvert	Minor
Km56+736	Irrigation Canal	Culvert	Minor
Km57+720	Irrigation Canal	Culvert	Minor
Km58+150	1st order tributary, Milk River	Culvert	Minor
Km58+336	Milk River	Culvert	Minor
Km58+520	Drainage	Culvert	Minor
Km59+100	Milk River	Bridge	Major
Km59+650	Milk River	Culvert	Minor

Flow measurements along the three main crossings, the Rio Minho, St. Anne's Gully and the Milk River, based on statistical analysis are presented below:

Table 4.10: Simulated and Measured Flow Measurements for the Main River Crossing

River and location	Return Period	Simulated Instant Maximum Flow (m^3/s)	Upstream Water Surface elevation (m)	1986 June Flood Peak Flows (measured / *estimated* in m^3/s)
Rio Minho at Danks (444 km^2 watershed)	100 year 50 year 10 year	– – –		– 2,460 –
Rio Minho at May Pen	100 year 50 year 10 year	3,038 2,577 1,369	53.3 52.7 50.9	*3,090*
St. Anne's Gully ($52km^2$ watershed)	100 year 50 year 10 year	208 171 92	45.6 45.3 44.5	– – –
Milk River at Scott's Pass ($80km^2$ watershed not including increased	100 year 50 year	131 102		– 121

River and location	Return Period	Simulated Instant Maximum Flow (m^3/s)	Upstream Water Surface elevation (m)	1986 June Flood Peak Flows (measured / *estimated* in m^3/s)
groundwater flows)	10 year	–		–
Milk River at Rest	100 year 50 year 10 year	1,826 1,116 300		625

Surface depressions or sinkholes associated with the hydrogeology of the area that fall within the highway corridor are noted at Km61+170, Km65+500 and Km65+710. The highway corridor will pass the outer rim of a man-made depression about 150m east of Km67+100 that at times is filled with water.

No springs are noted, however, there are several records that indicated that during significant rainfall events, several springs emanate from fractures within the limestone particularly at the base of the Melrose Bypass Hill, within and around Porus and several locations between Km57+000 to Km72+000.

The Redberry Cave is located approximately 550m southeast of corridor centreline at Km64+830. Given the geology, it is likely that other karst features may exist between Km59+000 and Km72+000 that have not been formally recorded.

4.1.8.2 Projected Water Demand

The highway will not have a significant demand on water resources, as the only constantly manned stations are the toll plazas, while all other users will be transient. Whilst during construction there will be demand for the use of water browsers for dust mitigation which can be significant in drought conditions as well as the needs on site bases, concrete plants, asphalt plant etc. this can be easily met and metered by the existing mains supplies from NWC and/or NIC.

4.1.9 Sewerage Facilities

The proposed route crosses several existing houses and other properties and while there are no municipal or community sewage treatment facilities on the route the older homes would have been constructed with absorption pits as the means of sewage disposal. These pits will typically be 3 – 4 m in diameter and of varying depths of up to 5 m. More recently constructed facilities, since the 1970’s, may have a septic tank and soak away.

Wherever a house or commercial building is located on the route there will be a pit.

4.1.10 Historic Flooding along the Proposed Route

The entire section of the highway corridor, from the Rio Minho crossing to Trinity has a long history of flooding with well documented flood-prone areas due in large part to its geology and hydrogeology. There have been several significant flood events in the recent past. Residents attribute these events to any new development within the general area. Events such as the June floods of 1986, the floods of May 1993 as well as the floods in Porus (May/June 2002) and Harmons (September 2002), October 2005 and June 2011 come immediately to mind by persons in the general vicinity largely due to the ease of recall. During 2007, several residents voiced concerns about the proposed highway corridor. NROCC engaged a consultant to undertake a flood risk management report. This section references that report and several other historical reports and newspaper stories along with the ODPEM Flood Registry in order to capture the historical flood events along the proposed highway corridor.

In order to put the area in context, the following section will outline the impacts of historical flooding along the corridor separated by flooding on the alluvial plains between the Rio Minho crossing to the western edge of Clarendon Park and from the limestone hills west of Clarendon Park to Williamsfield.

4.1.10.1 Rio Minho to Clarendon Park

This section highlights historical flooding along the Rio Minho to Clarendon Park section of the highway corridor:

- In the Porus and Harmons areas, it is reported that both areas experienced extensive flooding in 1933 and 1938 when the groundwater emergence at surface occurred in conjunction with significant flows on the Milk River due to prolonged rainfall. In 2002, a similar event occurred and several homes were flooded as shown in the map below.

Figure 4.58: 2002 Flooding in Porus with blue Dots showing the Number of Homes impacted by Floods

- During the May-June 1986 floods, which were arguably the worst floods in Jamaica's recent history, areas within the alluvial plain below May Pen were extensively flooded. Tobacco fields at Denbigh and Woodleigh were destroyed. The May Pen Highway Bypass bridge was extensively damaged and the northern abutment was eroded leading to collapse (Figure 4.31). Further downstream the bridge at Alley that crosses the Rio Minho had water levels 7 – 9 m above the bridge deck. At Ashley Hall flood waters reached as far east as the Monymusk factory. On the Milk River side of the alluvial plain at Spring Plains, the winter vegetable project was inundated. While the Milk River Bath Hotel had its ground floor completely flooded. Water levels were reported between 4 to 4.5m. (See Figure 4.59 and Figure 4.60 below). The Rio Minho/Milk River alluvial plains received the highest rainfalls and the largest peak flows and consequently the plains suffered the most severe damage of all areas across Jamaica during the event.

Figure 4.59: Rio Minho Highway Bridge Bypass with eastern abutment scoured out on 06 June 1986 (north to left of image)

Figure 4.60: Milk River Bath Hotel where 4.5m flood waters flooded the ground floor image taken from video footage shot on 06 June 1986. WRA flood simulations support Bath water levels of over 4m above the road surface (Source: Eleanor Jones, Flood Miitgation 1987)

- During 18 – 19 May 1993 eastern Clarendon experienced a significant rainfall event. It resulted in the unfortunate loss of eight people living within the floodplains of the “Rasta Gully”, one of the unnamed tributaries of Bower’s River. Though the rainfall was significant, flooding was exacerbated by the improper reinforcement of the Railway Bridge at Sandy Bay that in effect created a dam that is estimated to have flooded some 161,900 m^2 to a depth of 8m. The damning resulted in the catastrophic failure of the railway embankments on either side of the railway bridge that caused further downstream flooding and loss of life. Flooding as recorded by Mr. Lankester on the morning of 19 May 1993. Residents also recall that the during significant rainfall events the flood water within the gully overtops the bridge on to the road.
- At the Rio Minho, visual observations indicate that during significant rainfall events the river level at the Rio Minho overtops the current gabion baskets on the eastern embankment by some 10 – 12m.
- The section of the highway that traverses the Denbigh plains rests on the floodplains of the Rio Minho. It is reported that pre-1986 rainfall events completely washed away JPSCo’s distribution lines that ran roughly east-west across the Denbigh plains. Saturated ground conditions should be anticipated. Groundwater depth from the Denbigh Farms No.1 well is on average 6m below ground level (bgl).
- At Four Paths, on the main road to May Pen, it is reported that the bridge that spans the Jacks or St. Anne’s Gully had flood waters overtopping the bridge parapet in 1986. Immediately

upstream of the bridge, the community experienced significant displacement as houses adjacent the gully were flooded up to roof level 2 – 3m above ground.

- In June 2011, the ODPEM recorded flooding events within Osborne Store and Four Paths, however, the precise details were not recorded.
- The ODPEM reports that flooding occurred at Osborne Store, Toll Gate, and Four Paths during the torrential rains associated with a tropical depression of May–June 2002 and October 19, 2005. The 2005 floods occurred due to rainfall associated with Category 4/5 Hurricane Wilma. From the topographic maps, there is a very large sinkhole/depression in the Osborne Store environs approximately 1km north of Km53+800. Average groundwater level at the closest existing limestone groundwater well (St. Jago Tollgate 4km west of Osborne Store) is recorded at 20 m asl[5]. Given that sinkholes are natural depressions in surface topography, they act as a sink for surface drainage, and can also be areas that express groundwater at the surface during periods of rapid groundwater rise. Locals in the area indicate that drainage infrastructure seems inadequate. NROCC's flooding evaluation in 2012 outlined the following contributors to flooding: infilling of historic soak-aways and sinkholes; flat topography with insufficient drainage between major drainage gullies; localized depressions causing ponding; inadequate drainage along the older A2 highway; and heavy vegetation that restricts flow through existing drainage systems. Recommendations to improve drainage within Four Paths were also proposed and shared by NROCC with the local Parish Council. Images of historical flooding in June 2011 are shown below.
- Several areas within Four Paths that have experienced frequent flooding include Four Paths Town Square; areas to the west and northwest of the town centre; the area along the A2 highway; and areas immediately south of the A2 highway.
- At McGilchrist Pen (or St. Jago), no reports of flooding are indicated within the ODPEM database. However, residents indicate that localized flooding does occur along existing irrigation drains, especially where slopes are sufficiently gentle to limit conveyance rapidly downstream. The presence of several natural surface ponds appears to substantiate the reports of localized ponding. There is also reported flooding along the St. Jago main road.
- At Clarendon Park, in the vicinity of the fish ponds, several natural and constructed land drains converge between Km57+000 to Km59+000. The owner of the fish ponds has reported that during heavy rainfall, surface water originating from the hills north of the railway flows under the railway near the apex through a culvert and follows the drainage line that bisects the ponds before discharging into the irrigation canal and continuing east to the Jacks or St. Anne's Gully. It also reported that during heavy rains, the magnitude of flow from the hills

[5] Above sea level (asl)

north of the railway track washed out the railway line and its original culvert and flooded the area between the railway and the fish ponds. Given that this area a largely unpopulated, it is unlikely that reports would have been made to the ODPEM, hence, there is no record within its database. It was also reported in 2007 that during the construction of the large industrial complex in Clarendon Park, construction debris flowed through their property and along the land drains and canals. This suggests that the natural drainage flows toward the railway line from the plains to the south, and further, that the A2 main road may not significantly interrupt natural drainage in this area.

- The ODPEM records historic flooding at Toll Gate, but provides no further details. Work by NROCC suggests that flooding in Toll Gate is largely due to the Flemmings Gully adjacent to the older A2 highway. The reported contributing factors to local flooding in Toll Gate are inadequate drainage capacity in Flemmings Gully, particularly if overgrown with vegetation; undersized culverts beneath the A2 highway creating backwater conditions upstream during heavy rainfall as small as 1:10yr return periods; historic sinkholes being infilled; and overall inadequate drainage infrastructure. Several improvements were suggested to local Parish Council as a result of a flood impact report done in 2012 by NROCC.
- This segment of the highway is the area of highest risk of repeated flooding due to the presence of two significant river systems that discharge onto the Clarendon Plains – the Rio Minho to the east and the Milk River to the west. The fertile alluvial plains are the result centuries of repeated flood events through-out geological time. The account above outlines the more recent geological events; however, these events are not new and are an integral part of the hydrological system of the Clarendon Plains. These events, without proper planning, particularly with increased precipitation forecast by global warning, will potentially only become more devastating in the near future if sound and science led solutions are not adopted such as delineating the floodplains and developing regulations to prevent developments that encroach on demarked flood plains.

Figure 4.61: 2011 Images of Flooding in Osborne Store after Torrential Rains. Water Depth is over 1.5ft

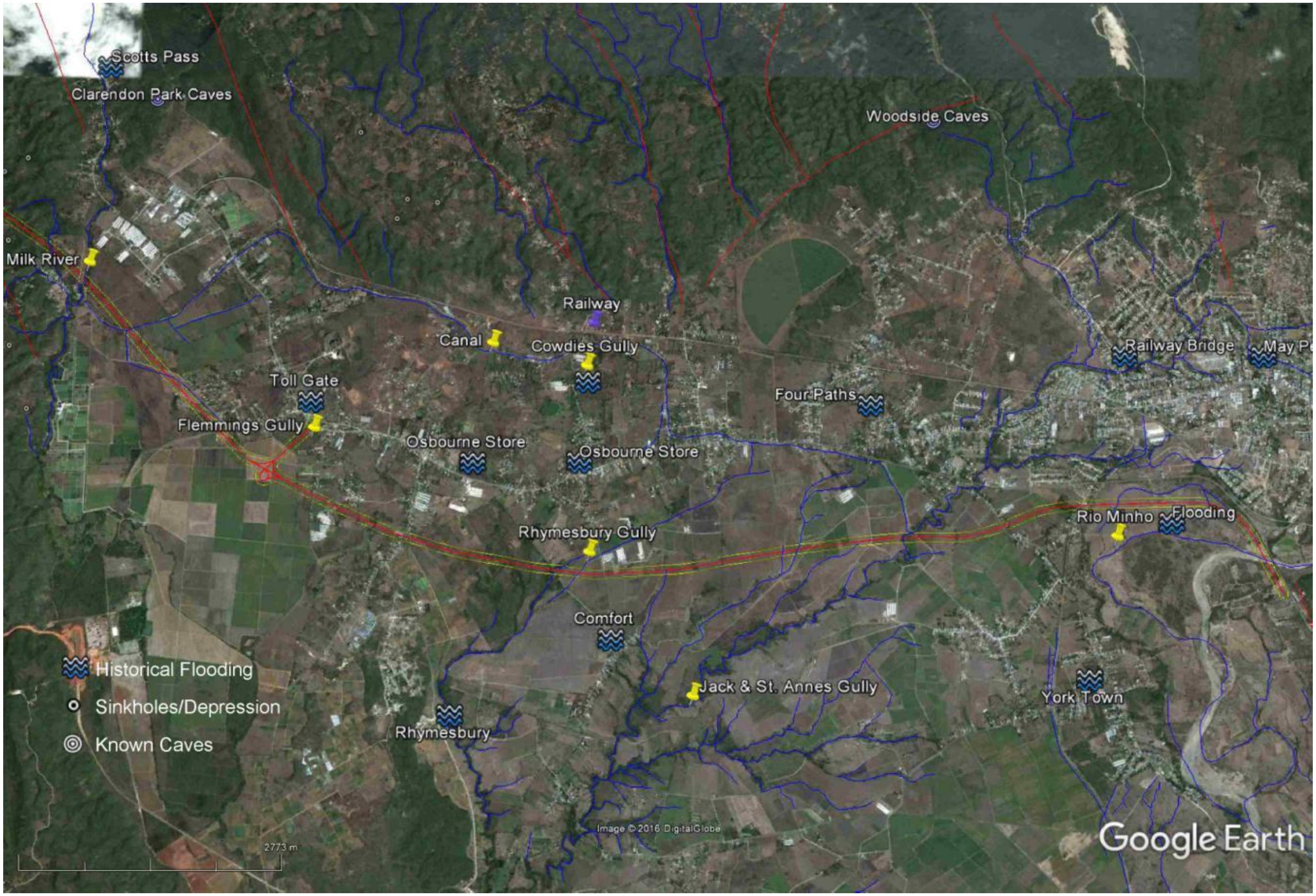


Figure 4.62: Rio Minho to Clarendon Park Historical Flooding Locations

4.1.10.2Clarendon Park to Williamsfield

This section outlines the historical flooding events on the highway corridor from Clarendon Park to the exit point at Williamsfield.

- At Berrydale, north of the corridor, a large sinkhole/depression (150m asl invert) is present. From the 1:12,500 topographic maps, it appears that the local main road through Berrydale bisects this sinkhole. Flooding, temporal springs and groundwater ponds were reported in Berrydale following the torrential 2002 rainfall event. The Jamaican newspaper, *The Gleaner* (June 28, 2002), reports that residents in the environs were seeking investors to develop the newly created water features (ponds and springs) as public attractions. These springs and ponds disappeared once groundwater levels returned to normal some months later.
- The 2002 flooding events at Berrydale, Trinity, Redberry, Porus, Melrose Bypass, St. Toolis, Toll Gate and Harmons are all connected to surface expression of groundwater, though they appear as separate events in time. Reports by the WRA shows that during 22 May to 12 June 2002, torrential rains dumped between 500 – >1500mm (200 – 490% increase over 30-yr. mean) of rainfall on to the highland areas of Manchester. This ultimately led to the flooding at Porus, Trinity, Berrydale and Redberry. Several depressions between Melrose Hill and Williamsfield were filled with groundwater and sequentially cascaded to depressions at lower elevations until ultimately discharging to the Milk River. One such depression reported by the WRA in 2002 is adjacent or possibly beneath the proposed highway centreline between Km66+800to Km67+200 (see Figure 4.64 below) Later that same year, two additional torrential rainfall events associated with Tropical Storm Isidore (Sept. 17–19, 2002) and Tropical Storm Lili (Sept. 24–29, 2002) created a hydrologic/hydrogeologic event that had not been experienced by residents in recent history. Events like these, that also cause flooding further south in Harmons, have been reported in the newspapers as far back as 1917.
- Groundwater level in the flooded areas of Porus ranged between 125 – 135m. Groundwater levels over the same area rose to between 137 – 152m. Several ponds and depressions along the Melrose Bypass road became filled with water as groundwater springs emerged at the base of these depressions. The WRA recorded surface flows during the May/June 2002 flood event ranging from 0.5 – 9.5m^3/s. The WRA estimated that approximately 80 million m^3 (an amount of water capable of filling 29 million 600 gallon black water tanks) of recharge water fell as rainfall during the period.
- Groundwater flowing along the principal flow direction within the graben, shown in the image below, is drained via the Milk River and/or the St. Toolis Spring. Redberry flows contribute to the Milk River and the groundwater from Melrose Hill also drains via Redberry. As the WRA noted that there was a positive correlation between increased flows at Melrose and the emergent groundwater flows at Redberry to the south. The total volume of water discharging from the groundwater system in May/June 2002 was estimated at 9 million m^3/s. Fractures along the Porus Road (at the foot of the Melrose Bypass) were reported by the WRA to be 4m deep with groundwater steadily flowing from them. This flow continued for several weeks.

- The WRA reports that the only real outlet for drainage in the Redberry area is a canal (that ultimately discharges to the Milk River) which is undersized and not able to carry the estimated flows from the Milk River coupled with groundwater input. This resulted in backwaters that led to further flooding. Additionally, the situation was exacerbated by the presence of a man-made log dam on the Milk River between Redberry and Spring Ground. This log dam was erected to retain water during the dry periods.
- Water budget calculations by the WRA had predicted that after three months groundwater levels would recede as outflows drained the surplus groundwater from the limestone aquifer. This was indeed the case and the springs and other flows declined to halt after about 3 months of constant flow.
- Not widely known is that the Williamsfield/Porus Graben system, is defined by the Whitney Fault to the east and the Queen Town Hill Fault to the west, and stretches from Mile Gully/Golden Grove in the north of Manchester, through Willamsfield/Porus and terminates over 20 km southeast in the St. Toolis area of Clarendon. This massive geological system governs both the hydrogeology and the topography within it. The numerous fracture zones within the graben act as preferential pathways for groundwater flow within limestone aquifer. It is when this groundwater emerges at the surface after torrential rainfall that extensive flooding occurs within the limestone hills and the alluvial plains. Melrose, Porus, Redberry, Harmons and St. Toolis represent the low points within the graben system and once groundwater levels are elevated above ground level, significant and prolonged surface flooding occurs.
- The WRA estimated that approximately 302 million m^3 (approximately 117 million nos., 600 gallon “black water” tanks) of water was added to the aquifer as recharge during the heavy rains. The estimated aquifer outflow was approximately 1.8 million m^3/day (an amount that could fill about 3,000 600-gallon “black tanks”).
- At Harmons, the WRA estimated that approximately 1.1 to 1.3 million m^3 was detained within the depressions. The flood level rose to the 167m (550ft) contour which would represent the groundwater level within the aquifer at the time. Drainage out of Harmons is quite restricted and generally occurs via vertical drainage into the subsurface. With groundwater elevated, Harmons drained only after the springs at the base of Melrose Hill had receded.
- Historical flooding at the drainage crossing along the Redberry main road and at Watermouth has been recorded and is caused by undersized drains that restrict flow and inundates the residences upstream. Overtopping of the roadway has also been reported. Watermouth has significant baseflow from artesian groundwater and flow depth at the crossing can be as high as 1m with a relatively high flow velocity.
- In Trinity, which is west of Porus and in the vicinity of the intersection of the A2 highway and the Melrose Hill Bypass, flooding has been recorded during the 2002 and 2006 rainfall events. The flooding was due to groundwater emergence at surface. Groundwater springs flowed for a significant period after the storm events. The highway was raised in 2002, but the modifications have not completely reduced the flooding issues in the area.

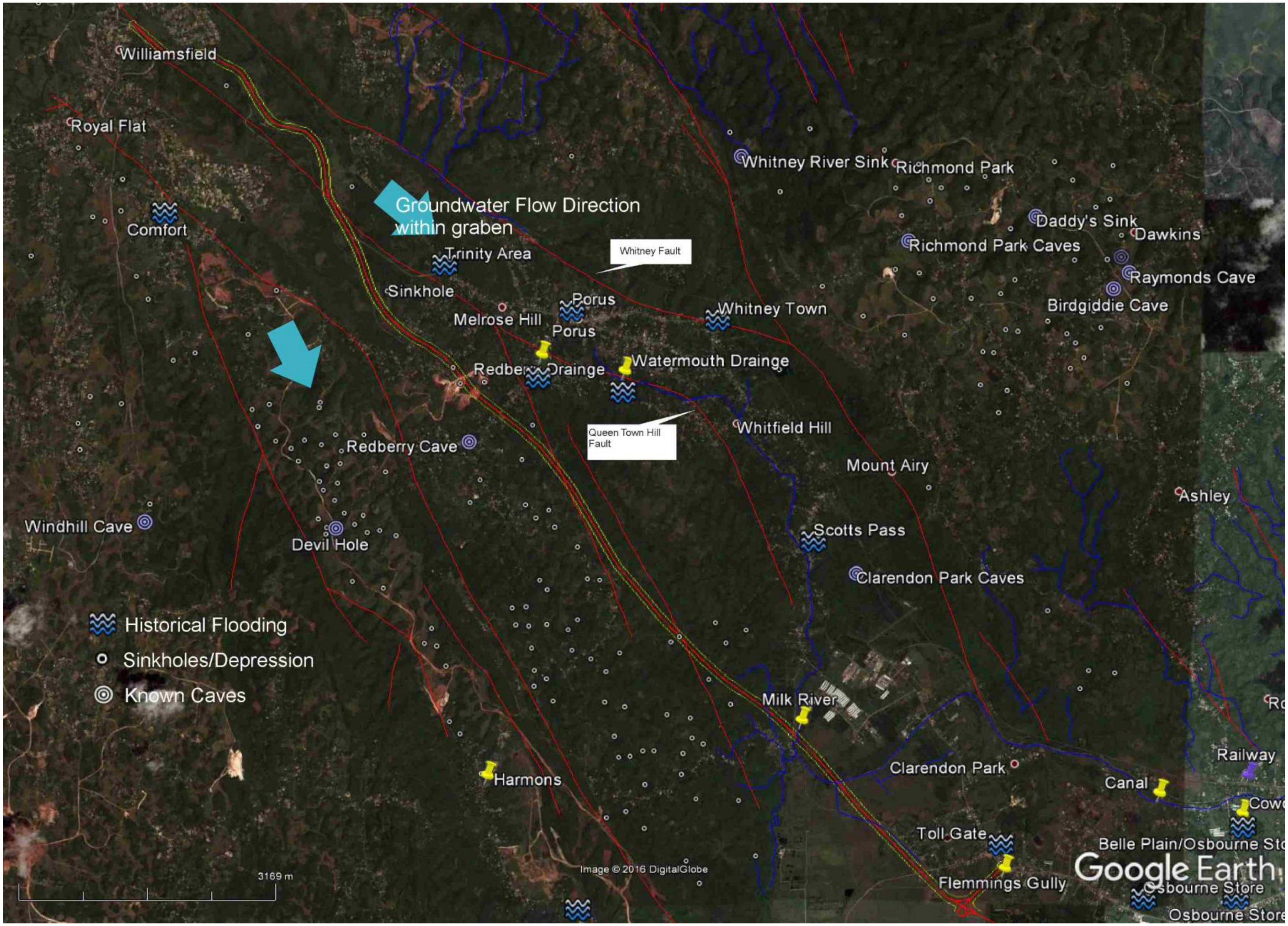


Figure 4.63: Clarendon Park to Williamsfield Historical Flooding Locations

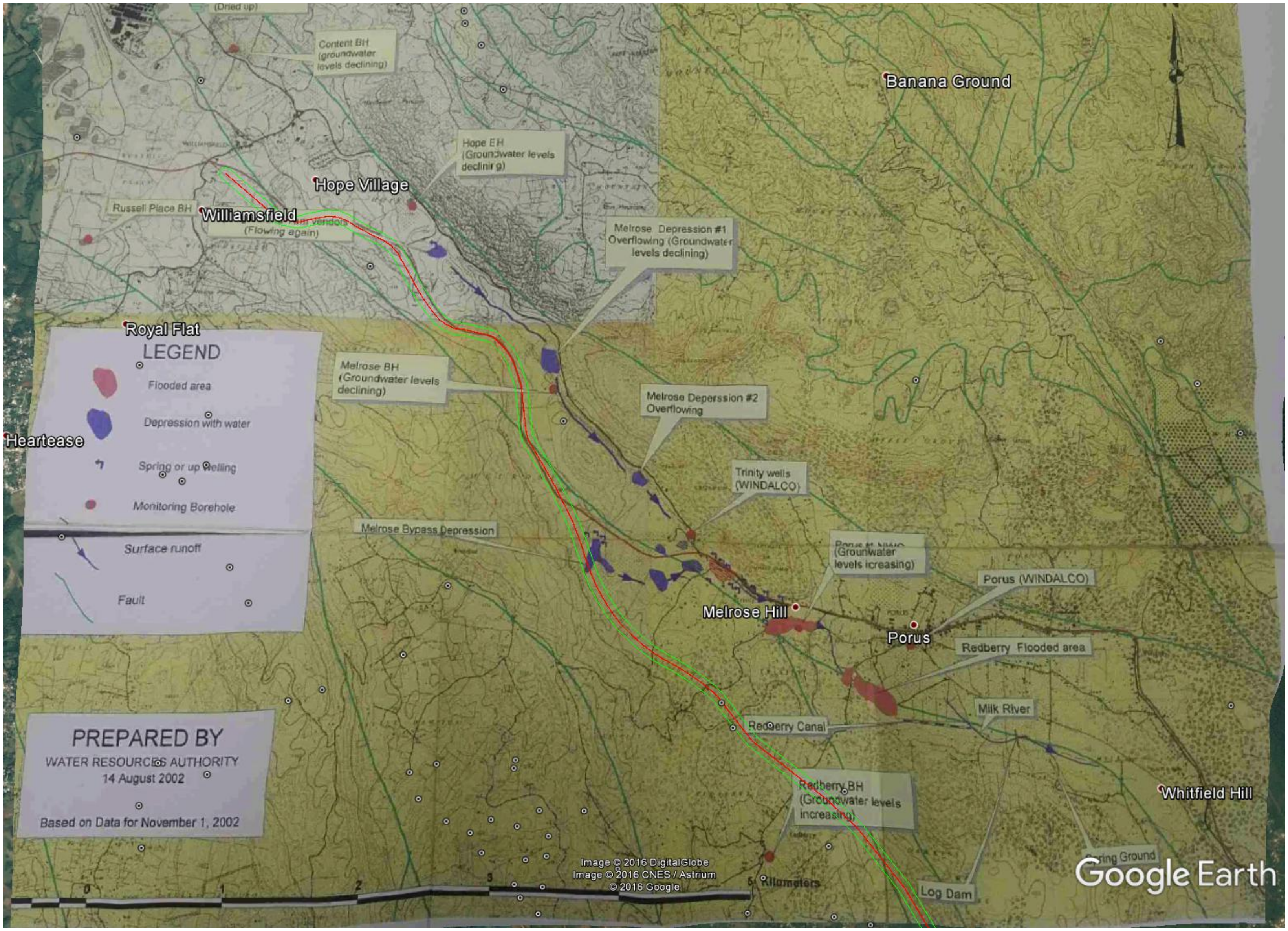


Figure 4.64: Clarendon Park to Williamsfield segment overlain on WRA 2002 Porus flood map. Flooding between Km70+200 to Km68+700

Table 4.11: Summary of known areas of flooding between Four Paths to Williamsfield (based on ODPEM and media reports)

LOCATION/Local Name	Description
Four Paths	Flooding occurs along Four Paths main road and settlement (depression?) near the scheme, largely due to poor drainage infrastructure. Typically occurs after 1 to 3 days of sustained rainfall. Four Paths Town Square including areas to the west and northwest of the town centre; sections of the A2 highway through and to the west of the town center and areas immediately south of the A2 highway. Runoff from the foothill areas north of the railway corridor also contribute significant runoff to Four Paths and Clarendon Park.
Osborne Store Area	During heavy rainfall, due to old drainage infrastructure (circa 1940s to 1950s), gullies and drains are flooded. It is reported that runoff from the hills to the north flow through Belle Plain and into Osborne Store causing flooding.
Rock Road	Flooding occurs typically after 1 to 2 days of sustained rainfall with flooding toward Osborne Store.
Toll Gate	Flooding is known to occur on the St. Jago Road.
Scotts Pass	Typically with sustained rainfall for 1-2 days the Scotts Pass Road floods. It is thought the adjacent river over-tops onto the road.
Spring Grove District	Numerous groundwater upwelling/spring occur during sustained rainfall, the groundwater spring flow towards the Milk River. Flooding also occurs in Berrydale close to Scotts Pass.
Redberry	At Redberry the main road floods, and it is believed by residents that a ‘river” runs underground.
Porus	Flooding is reported in front of the Police Station and on the main street.
Trinity Area Road	Flooding on the main road occurs during heavy and sustained rain.
Williamsfield Area	Depressions fill with water, during the 1986 and 2002 rainfalls several depressions filled with runoff and groundwater cascaded sequentially downgradient toward the Milk River.

4.2 BIOLOGICAL ENVIRONMENT

4.2.1 Habitat types, vegetation and ecological functions

The entire study area was strongly influenced by human activities and therefore highly disturbed. The vegetation zones were influenced by gradients of elevation, rainfall and disturbance, as well as geology and drainage patterns. More than 220 species of plants were encountered in the surveys (Appendix IV), the majority of these were common and widespread in Jamaica. A few endemic species were found mainly in the forested areas around the community of St Toolis, however, this is to be expected because this area had pockets of less disturbed woodlands. A general habitat characterization is illustrated in Figure 4.65.

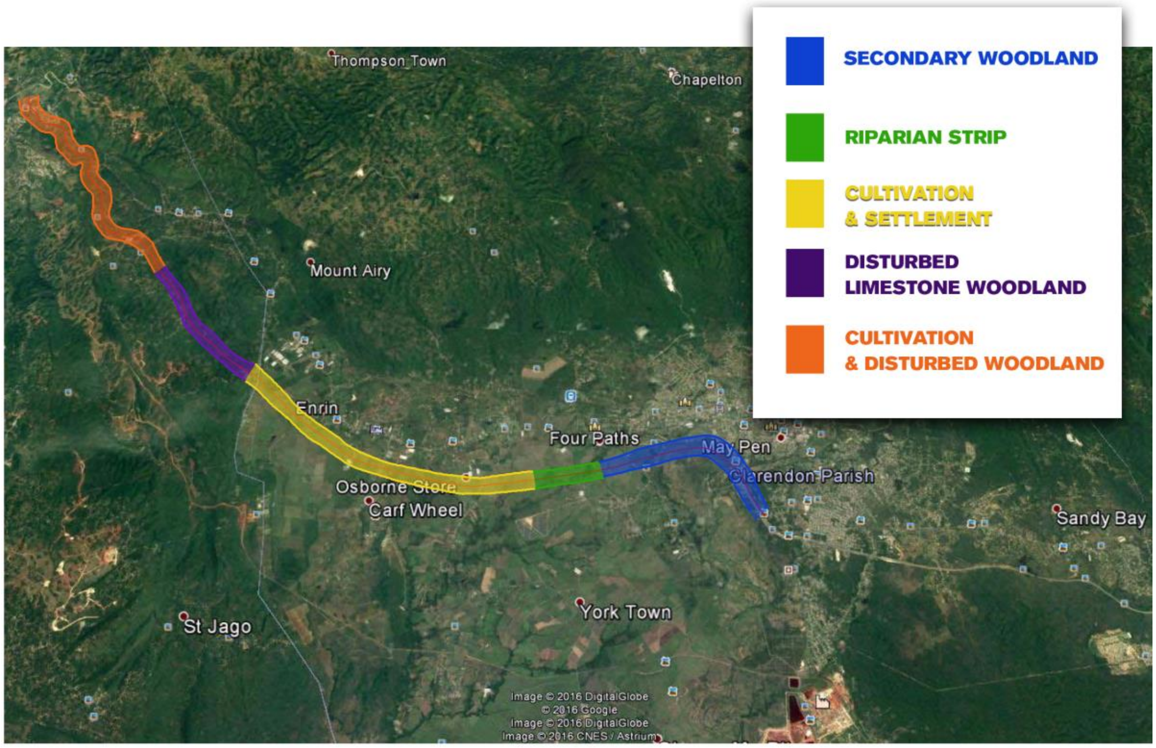


Figure 4.65: General habitat characterization of the alignment of the H2K (May Pen to Williamsfield)

4.2.1.1 Alluvial plains

The composition or structure of the natural vegetation that originally characterized the alluvial plains of south central Jamaica has been totally extirpated, and there are no records of its composition. This area has historically been under intense agriculture with the cultivation mainly with sugar cane and this long term disturbance means that all of the natural or semi-natural vegetation has been removed and only remnant secondary pockets remain in fallow areas.

Starting from the end of the existing Highway 2000 at the May Pen Bridge the route runs across flat, alluvial agricultural land characterized by sugar cane *Saccharum offinarum*, abandoned cane and tobacco *Nicotiana tabacum* lands with ruinate woodland (Figure 4.66). Canals and streams with narrow strips of riparian vegetation cross the alignment in this area with mixed agriculture and pasture as well as occasional housing plots in small residential communities. The Rio Minho River is generally dry where the alignment crossed the river and this zone does not support a riverine strip typical of water ways. The entire lowlands zone is located in the Vere Plain and is a part of the flood plains of the Rio Minho and the Milk River. The upper watersheds of these rivers are largely deforested or converted to agriculture, thus these flood plains are prone to major flooding whenever there are heavy rains. The frequency and intensity of such flooding is expected to increase with climate change. The semi-permeable alluvial soils also contains clays which tends to retain standing water in shallow depressions for considerable periods after heavy rains resulting in the formation of ponds.

Figure 4.66: Overgrown Sugarcane along Denbeigh Road (left); Mixed Grassland at Osborne Store (right)

Ruinate woodland on alluvium

There are a few small areas of woodland in the study area, mostly characterized by species that are resistant to grazing by goats and cows. Almost all of the large trees were Guango *Samanea saman* or fruit trees such as Mangoes *Mangifera indica,* which occur mainly along field boundaries and along canals and streams. This area also includes Cashaw *Prosopis juliflora*, various acacias (including *Acacia tortuosa*) and Coolie Plum *Ziziphus mauritiana*, Ironwood *Leucena leucocephala* and Bastard Cedar *Guazuma ulmifolia*. Ground cover includes non-native grasses such as Seymour Grass, Guinea Grass and many shrub species such as *Tecoma stans,* Ebony *Brya ebenus* and dense growth of vines such as Nightshade *Urechites lutea,* Coralita *Antigonon leptopus, Ipomoea* and Wall Saddle *Cissus microcarpa. Tillandsia recurvata* occurs commonly on electrical wires in the area (Exampes shown in Figure 4.67).

Figure 4.67: Coolie Plum (left); Night shade (right)

Grass pastures

Abandoned cane lands have reverted to Seymour Grass *Andropogon pertusus* and are used for grazing goats and cows. There are scattered small trees such as Cashaw, *Acacia* and *Leucaena*. The grasses that dominate the rough pastures are all introduced (Table 1 of Appendix IV) (Examples shown in Figure 4.68).

Figure 4.68 Napier grass (left); Piano grass (right)

Sugarcane

Sugar cane is grown as a monoculture in fields separated by interval roads which are dominated by grasses and a few roadside weeds.

4.2.1.2 Freshwater habitats

Freshwater habitats in the zone of influence of the highway alignment include the Milk River, Rio Minho and several small streams and irrigation canals. There are also some small natural ponds in the general area. A few ponds are constructed for the use in aquaculture but several ponds appear to be naturally formed in depressions or constructed as mini reservoirs along streams in the area. The rivers and streams have dense vegetation typical of a riparian environment including large trees on their banks. This vegetation is important for protecting the integrity of the banks, reducing soil erosion and capturing sediments. The rivers include complex habitats that support a variety of fish and invertebrates. They also function as possible migration routes for various species including pond turtles. Thus it is important that the rivers and streams and their vegetation should be protected and that they should not be further channelized.

Riparian vegetation

The riverbanks are dominated by large Guango and Almond trees *Terminalia catappa,* with dense growths of vines, including the introduced Coralita and several species of *Ipomoea* spp*. Ludwigia peruviana* also occurs in some places. Other plants include sedges, Giant Swamp Fern *Achrosticum* sp., Water Grass *Commelina diffusa* and Wild Plumbago *Plumbago scandens* (Some examples shown in Figure 4.69).

Figure 4.69: Sedges at Four Paths Stream (left); Wild Plumbago (right)

Freshwater aquatic vegetation

Most of the streams are relatively slow flowing. Deeper slower moving sections have rooted vegetation including *Potomogeton nodosus* and *Ceratophyllum demersum.* The exotic invasive aquatic plant *Hydrilla verticillata,* has also been observed in some areas. Shallow stream edges often support sedges *Cyperus spp*.

Rio Minho

The Rio Minho is one of the largest rivers in Jamaica. Although its bed is usually dry at the section where it passes under the May Pen Bridge, it does have seasonal flow when there is rain in the upper watershed and is subject to major flash flooding. Also there are large washouts (depressions in the stream bed) in the area beneath the bridge that sometimes retain water for extended periods following stream flow. These ponds do not last for more than a few weeks to a few months and usually do not persist long enough to support aquatic vegetation. The river has been known to flood over the existing road bridge.

Milk River

The upper Milk River flows parallel with the existing road to Porus through the valley at Scotts Pass then flows south along the base of the limestone escarpment between Clarendon Park and St Toolis. The river is usually no more than a small stream in this location and sometimes dries in sections.

4.2.1.3 Mesic forest on limestone with scattered rural settlement, cultivation and bauxite mining

Elevation of the route starts at less than 200 ft. above sea level at Clarendon Park and runs over 900ft through wooded limestone hills in the vicinity of the community of St Toolis and the Upper Milk River Valley Scotts Pass and Porus are located. The soil is mostly limestone interspersed with pockets of bauxite and shallow pockets of topsoil. The hill tops are dominated by mesic forest on limestone with very little soil. The depressions generally contain somewhat deeper soils and these areas are usually supporting cultivation of mixed crops or larger fruit trees. Some of these valleys have already been mined for bauxite. The mined out areas do not often have much vegetation re-established within the pits.

Mesic forest on limestone

On the hillsides, common species included West Indian Cedar *Cedrella odorata*, Broadleaf *Terminalia latifolia, Leucena,* Prickly Yellow Xanthoxylum fagara. Steep rocky banks supported endemic species such as Maidenhair *Ferns spp*. and *Portlandia Portlandia sp*. (probably grandiflora), thatch palms *Thrinax parviflora* and a few large trees supported orchids such as *Encyclia frangrans*. However most of the large timber trees have been removed and the forests are highly disturbed.

Figure 4.70: Prickly Yellow (left); Thatch palm (right)

Caves

Caves are important for many species of animals, including bats and invertebrates and often house cultural remains. They are frequent in limestone areas, and their presence might be expected in this area. However, this survey found no evidence of caves in the literature, and local people did not report any caves in the immediate area.

4.2.1.4 Rural settlement and cultivation

The alignment corridor cuts though small cultivations and homes with well-established gardens, which include typical fruit trees including Mangoes, various *Citrus* species, Star Apples *Manilkara sapota,* Tamarind *Tamarindus indica*, Avocadoes *Persea americana* and ornamental plants such as Crotons *Codiaeum variegatum*, Ixora *Ixora coccinea* and Bougainvillea *Bougainvillea glabra* and the June Rose *Lagerstroemia indica*. Larger ornamental trees including Poinciana *Delonix regia*, Cassia trees *Cassia fistula*, African Tulip *Spathodea campanulata* and Yellow Poui *Tabebuia rufescens* are also common. There are also several small plots of mixed cultivation scattered around the areas with Cassava *Manihot esculenta* being the most common (Examples shown in Figure 4.71).

Figure 4.71: Cassava field (left); Crotalaria and Pawpaw (right)

Riparian vegetation

The banks of the upper Milk River are lined with highly disturbed riparian woodland, most of which has been replaced by food and timber forest and crops, which form the basis for the local economy. Porus was one of the first free villages and the community has a long tradition of selling fruits on the roadside.

There was probably once a distinct riverine community but so many trees and other crops have been planted that its botanical composition is indistinguishable from the surrounding area, except that the increased availability of water results if more luxuriant growth and larger trees. Other common fruit trees include Naseberry *Manilkara sapota,* Guinep *Melicoccus bijugatus*, Sweet Sop *Annona squamosa*, Soursop *Annona muricata*, Custard Apple *Annona reticulata*, Otaheite Apple *Syzygium malaccense,* Citrus *Citrus* species, Breadfruit *Artocarous altilis,* Ackee *Blighia sapidum,* Coconuts *(Cocos nucifera),* Mango *Mangifera indica* and many others. Where the canopy is open there may be dense growth of vines *Ipomoea* spp. Bananas and Plantains (*Musa* spp.), Pumpkin, dasheen (*Coloclasia esculenta*) and sugar cane *Saccharum officinarum* are cultivated on the fertile banks of the river. Scratch Coco *Coloclasia esculenta* and various species of watergrass *Commelina* spp. are also present. A narrow strip of riparian vegetation can be found along canals and streams in the Four Paths and Osborne store area but this is minimal.

Bauxite mining

Several areas within the Limestone hills are currently being mined. These areas often have very deep pits with very little vegetation growing in the pits. Some pits had stands of Oil Nuts *Ricinus communis* growing inside or on the sides of the pits (Figure 4.72). Although no mining was observed in areas closest to the alignment trucks bringing ore from other mines were observed driving along mining roads in the area.

Figure 4.72: Oil Nut

4.2.2 Fauna

4.2.2.1 Birds

More than 100 species of birds were observed in the study area during field visits (Figure 4.73). Several additional species are also included in the final list of birds because they have previously been observed by the authors and are known to occur in these habitats and could be expected to be detected in more extensive surveys (Appendix IV). Twenty two of Jamaica's twenty nine extant endemic species were observed in the field in the vicinity of the alignment. These are the more common and widespread species that will occur in disturbed forests. None of the rare endemics (that are dependent on natural forests) were observed in the area and this is a result of the highly disturbed nature of all the habitats along the alignment.

Figure 4.73: Cattle Egret colony ay Osborne Store in Clarendon (left); Herons and Egrets (right)

4.2.2.2 Reptiles

The most common reptiles were *Anolis* lizards, which were observed throughout the woodlands, residential and cultivated zones. Common reptiles included anoles such as *Anolis lineatopus* and *A. grahami.* Geckos *Aristelliger praesignis* were common and were frequently detected from their calls.

The American Crocodile *Crocodylus acutus* is a globally threatened species and is therefore of special concern. Crocodiles might visit the fish ponds via the rivers and streams in times of drought or food shortage but this is probably quite rare. They are abundant in the lower reaches of the Milk River and Rio Minho but were not observed or reported in the area of the alignment but this may be due to the fact that this section of the river is often dry at Rio Minho or small and inadequate for adult Crocodiles at this section of the Milk River. They have not been reported from Porus.

The endemic pond turtle or Jamaican Slider *Pseudemys (Trachemys) terrapen* is known to inhabit the area and is common in fish ponds, rivers and streams. Little is known of the ecology of this species. Although it is known to migrate, it is not known whether its movements are strictly seasonal or simply in response to water levels mediated by rainfall frequency and drought. The highway might be a major impediment to any such migrations, but in the absence of detailed information about the size of the local population or migration patterns in general, it is impossible to assess the impacts or determine whether mitigation measures will be needed. As a general principle it will be easier for them to move if the existing drainage channels that traverse the alignment are allowed to remain in conduits that are wildlife friendly. Based on the high risk of flood as a result of run off from the upper watershed, this would appear to be a prudent measure to reduce the risk of flood water backing up to the north of the highway.

4.2.2.3 Amphibians

Cane Toads *Bufo marinus* have been observed throughout the area. This alien invasive species was more common in moist areas. Other frogs were heard during evening visits to the site, the most common was the introduced, invasive Johnsons Robber Frog *Eleutherodactylus johnstoni*, which was very abundant in the wooded areas and gardens. The Laughing Frog *Osteopilus brunneus* and the Jamaican Snoring Frog *Osteopilus crucialis* were also detected during evening visits to the area. These are common in moist mid-level forests particularly in areas with abundant tank epiphytes such as *Hohenbergia* sp..

4.2.2.4 Mammals

The only mammals observed in the study area were the Small Indian Mongoose *Herpestes javanicus,* Brown Rats *Rattus norvegicus* and at least two species of bats. Bats were not abundant at any of the nocturnal bird survey points. The few bats that were observed in flight could not be identified without a bat detector. The presence of the endemic Jamaican Fig-eating Bat *Ariteus flavescens* is known from the Mandeville areas and might be expected for the area. This species is one of two endemic bats and twenty one known from Jamaica, it does not generally roost in caves.

4.2.2.5 Aquatic animals

Observations of the offerings of roadside vendors indicated that the most common shrimp in the Milk river is the introduced Red Claw (*Cherax quadricarinatus*). This was confirmed by discussions with the vendors in Scotts Pass who reported that native shrimps have become uncommon. At least one species of mosquito fish ‘ticky-ticky’ fish (as yet unidentified) were seen in the rivers and canals. The residents in the Four Paths area indicate that Perch *Tilapia mossambica* are caught for food in the river and the Pond Turtle *Pseudemys terrapen* are caught and sold mainly as pets.

4.2.2.6 Keystone species

Keystone species on the alluvial plains include the large Guango trees, which provide food and a refuge for many species of birds and insects. In the forested areas, large Cedar, Silk Cotton and Fig *Ficus spp*. trees are of special ecological importance, as are the Zebra butterflies and their *Passiflora* food plants. Large birds particularly pigeons, especially the White-crowned Pigeon *Patageionas leucocephala*, play an important role in seed distribution in the forests.

Figure 4.74: Ficus Sp.

4.2.3 Threatened and Endangered Species

4.2.3.1 Plants

The road corridor passes through highly disturbed alluvial plains (which were converted for sugar plantations hundreds of years ago) and limestone uplands (which have been disturbed by cultivation, selective harvesting of timber and sticks and grazing). Both areas support many non-native and invasive species. The sites that are most likely to support threatened species of plants are the freshwater streams and canals, and the less disturbed areas of mesic forest on steep slopes and rocky hill tops. However, no threatened plants were encountered. Species of interest include *Portlandia*, a Jamaican endemic genus, which is yet to be rated by IUCN but is expected to be categorized as threatened, based on its limited range.

4.2.3.2 Birds

Only 22 of Jamaica’s 29 extant endemic species were encountered during the visits although a few more may occur occasionally the rarest species which are often the most dependent on natural or old growth forests are largely absent. No threatened (IUCN) species were present.

4.2.3.3 Amphibians and reptiles

The Jamaican Slider is classified as Vulnerable by IUCN. American Crocodile is Vulnerable and a protected species in Jamaica. Although they were not observed during the survey but they are expected to occur. The Jamaican Snoring frog is listed as endangered (IUCN) and is locally common in the area.

4.2.3.4 Other species

Several species of Butterflies were observed but all species identified were common and widespread in similar habitats island-wide. Some were endemic to Jamaica but were not endangered e.g. *Battus polydamus*.

4.3 SOCIOECONOMIC ENVIRONMENT

4.3.1 The Zones of Impact

Collectively, the communities crossed by the alignment or close to it define zones within which immediate and cumulative project impacts, or degrees of same, will be experienced. However, the impacts of the project will permeate well beyond these limited zones, particularly the travel time reduction impacts and the development generation effects.

Special attention was paid to the following zones that fall into these spatial classifications:

- The 1km buffer zone around the alignment;
- The 2km buffer zone around the alignment;
- The 3km buffer zone around the alignment.

Special attention was also paid to:

- The Enumeration Districts (EDs) through which the alignment passed;
- The EDs immediately adjacent and contiguous to the EDs through which the alignment passed.

Based on a Google-determined assessment, the Consultants placed the following communities into the 1 to 2km project zones, which are considered to represent the most immediate impacts, particularly construction dislocation.

Table 4.12: Communities of Most Immediate Impacts within the 1–2KM Buffer Zones

	Clarendon
1	Content Village
2	Four Paths
3	Osborne Store
4	Clarendon Park
5	Decoy
6	Toll Gate
	Sub Total Clarendon 6
	Manchester
7	Scott's Pass
8	St. Toolis Lower
9	Porus
10	St. Toolis Upper
11	Melrose Hill (Vendors)
12	Royal Flats/Willamsfield Gardens
13	Williamsfield
14	Hope Village
15	Melrose
	Sub Total Manchester 9
Total	**15**

The communities and their neighbourhoods, as listed above in Table 4.12, were investigated using the rapid appraisal approach. Within the 3km buffer zone, all of the above communities are impacted, along with some sections of the town of May Pen and Mandeville. These latter sections were not included in the rapid appraisal.

The total number of interviews conducted during the rapid appraisal survey was 300. This was considered to be sufficient to bring into focus those positive or negative impacts that the communities and stakeholders are likely to perceive. Population data for these communities are presented in the following section.

4.3.2 Present and Projected Population

Current and projected population estimates within the selected buffer zones of the alignment are presented in Table 4.13 below.

Table 4.13: Population by Buffer Zones and Population Projections 2011–2030

2011	2015	2020	2030	2035
1km Buffer Zone				
15,389	17,168	20,282	23,840	26,063
2km Buffer Zone				
45,322	50,561	59,729	70,208	76,757
3km Buffer Zone				
78,199	87,239	103,059	121,138	132,438

The assumption used is that the population growth rate will continue at a rate similar to its most recent 10-year annual average rate. The Statistical Institute of Jamaica's (STATIN) population projections by parish may differ as more sophisticated forecasting models are used. No official projections are made below the parish and parish capital level. An early request to STATIN for population projections from 2011 to 2035 has not yet been provided. If received, they will be incorporated into the final report. The approach used limits population increase to a recent historical trend and does not factor potential in-bound migrations due to projected H2k induced developments.

Figure 4.75, showing the EDs through which the alignment runs and the adjoining EDs, illustrates that the distribution of non-overlapping population, along the alignment within each zone, is smallest in the 1km buffer zone (15,400), and fairly uniform in the 2km (30,000) and 3km (33,000) buffer zones. This distribution is mainly influenced by the inclusion of sections of the two parish capitals in the 3km buffer zone. Roughly two-thirds of the populations in all 3 buffer zones fall within Clarendon and one-third within Manchester. Because of the limiting assumption used, the inference is that this ratio will remain fairly constant over the range of projected years.

The demographics of this population is likely to reflect that of the respective parishes in that typically 50% of the population will be females and 50% males.

More recently, the population pyramid of Jamaica is showing a swing towards an ageing population. An inspection of the 2011 data reveals that the shape of the population pyramid for both parishes appears to be generally reflective of that of Jamaica. STATIN calculates this national shift as representing an increase of 15% in the working age related population and a 17% decrease in the under 15–year age group, when comparing the censuses of 2011 and 2001. The project is not impacted by these demographics, neither will these demographic age cohorts be discriminated by project impacts during the construction and operating phases. However, individuals and groups of individuals will be impacted. In Section 6.2.3, vendors, displaced vendors and directly impacted households have been discussed.

4.3.3 Land Use

Land use within the 3 buffer zones can first be described in relation to parish boundaries.

After crossing the Rio Minho, the alignment moves through a significant area of former agricultural sugarcane lands. Currently, these reflect the uncertainty of sugar production in Clarendon as these lands mainly comprise degraded pasture land and uncultivated holdings with stretches of commercial agricultural production. Chicken farming is an important land use activity with several medium-sized chicken holdings. Interspersed within each buffer zone, both to the north and south along current roadways, are linear roadside communities comprising a mix of housing types and commercial activities. The communities of note are Content Village, Denbigh, Four Paths, Osborne Store, and Clarendon Park. Business losses, due to traffic diversion, are foreseen by communities such as Osborne Store and Clarendon Park. Residential land use is, however, relatively low-density.

The alignment itself does not significantly alter land use in this part of the alignment, although it does impact some residential, religious, commercial and farming structures. Neither does it fragment communities or infringe significantly social right of ways. This latter is elaborated on below.

Once the alignment leaves Toll Gate in Clarendon, it crosses the Manchester border to the south west of Scotts Pass and ascends through elevated hilly areas to traverse Lower St. Toolis to the south, Porus to the north and Upper St. Toolis to the south. The land use becomes mainly forest land interspersed with pastures, mining activity and infrequent settlements.

When buffer zone 3 is assessed, a section of May Pen (Bushy Park) and a section of Mandeville (Heartease) are included.

A general characterization of the three buffer zones is as follows:

1km Buffer Zone

The population is estimated to be approximately 15,400, which represents 20% of the population contained within all three buffer zones. The proposed alignment in Clarendon includes five communities: sections of Four Paths; Content Village; Osborne Store; Decoy; and a significant portion of Toll Gate. In Manchester, the contributing populations arise from a portion of Upper St. Toolis, Porus, most of the Melrose Hope Village, Royal Flats and Williamsfield.

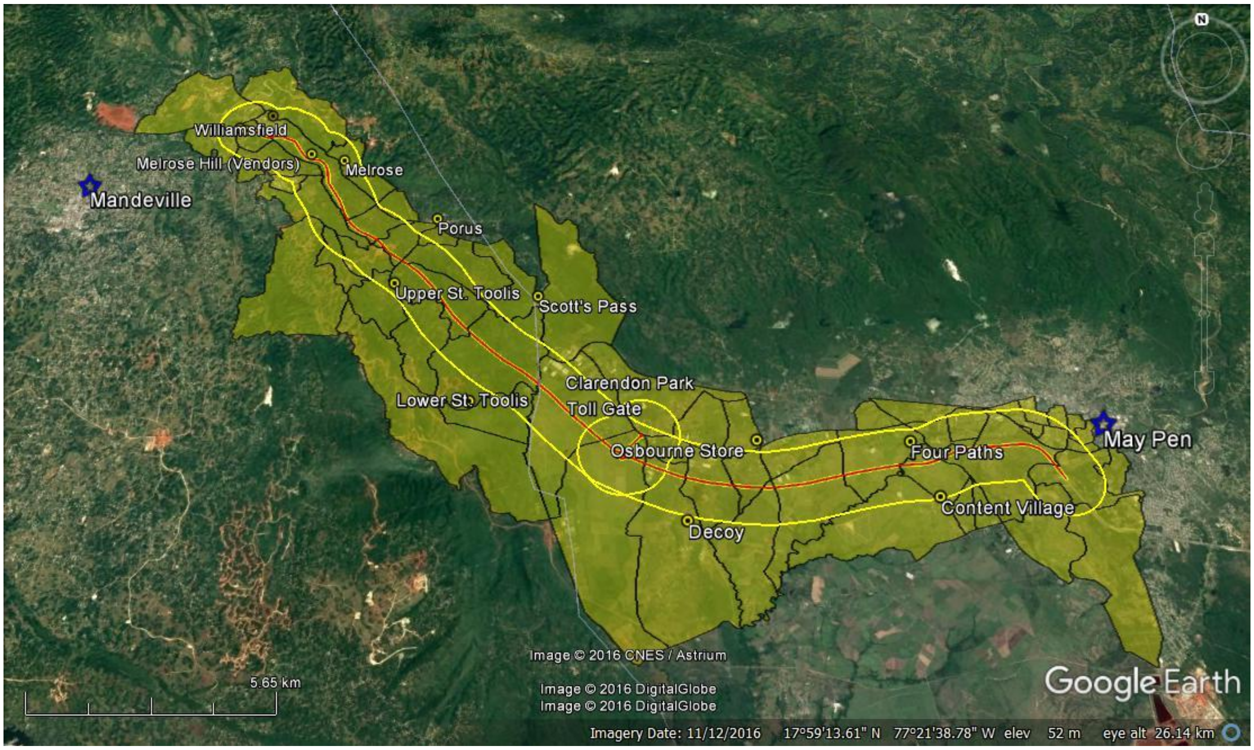


Figure 4.75: Map showing Location of Communities surveyed in relation to the proposed Alignment Yellow Sections represent those Enumeration Districts that are impacted within a 1km Buffer around the Alignment. The estimated total Population of those impacted within a 1km Buffer is 15,400.

The land use zones are broadly grouped as residential, commercial, agricultural farming and mining. Land not falling into these categories is unutilized and is mainly forest cover and scrubland – whether ruinate pastures or mined-out land.

In Clarendon within the 1 km buffer zone, land use is mainly agricultural, which includes chicken farms, pasture lands, and other crops. Poultry production throughout the three zones is predominately located in the 1 km zone. Farm size is typically 5 acres and under, but the bulk of the commercial production comes from much larger holdings. Residential use is the second main land use within this zone.

Six of the communities of interest are partially located in this zone. The communities having the largest footprints in this zone are Four Paths and Toll Gate. The others have less of a presence.

Because the main A1 road from Mandeville to May Pen passes through sections of this zone, small scale commercial activity, in the form of roadside vending is an important consideration.

Mining within this zone is mainly for sand in the Rio Minho bed at the start of the alignment. Unutilized lands are interspersed with agricultural and residential land use.

In Manchester, the majority of the land is unutilized. This is an intentional design feature of the highway, as it minimizes conflict issues. Lands in this region are sometimes within the bauxite mining reserves and may either have been mined, restored, or are awaiting restoration, or mining.

The main residential land use areas are Upper St. Toolis, Williamsfield, Royal Flats and Hope Village (Figure 4.76).

Figure 4.76: Residential community of Hope Village

No large-scale agricultural land use was observed, although small-scale farming is one of the more important reported economic activities.

Because the main A1 road from Mandeville to May Pen only passes though the 1km zone at the Melrose Bypass, the main commercial activity in this zone is yam vending.

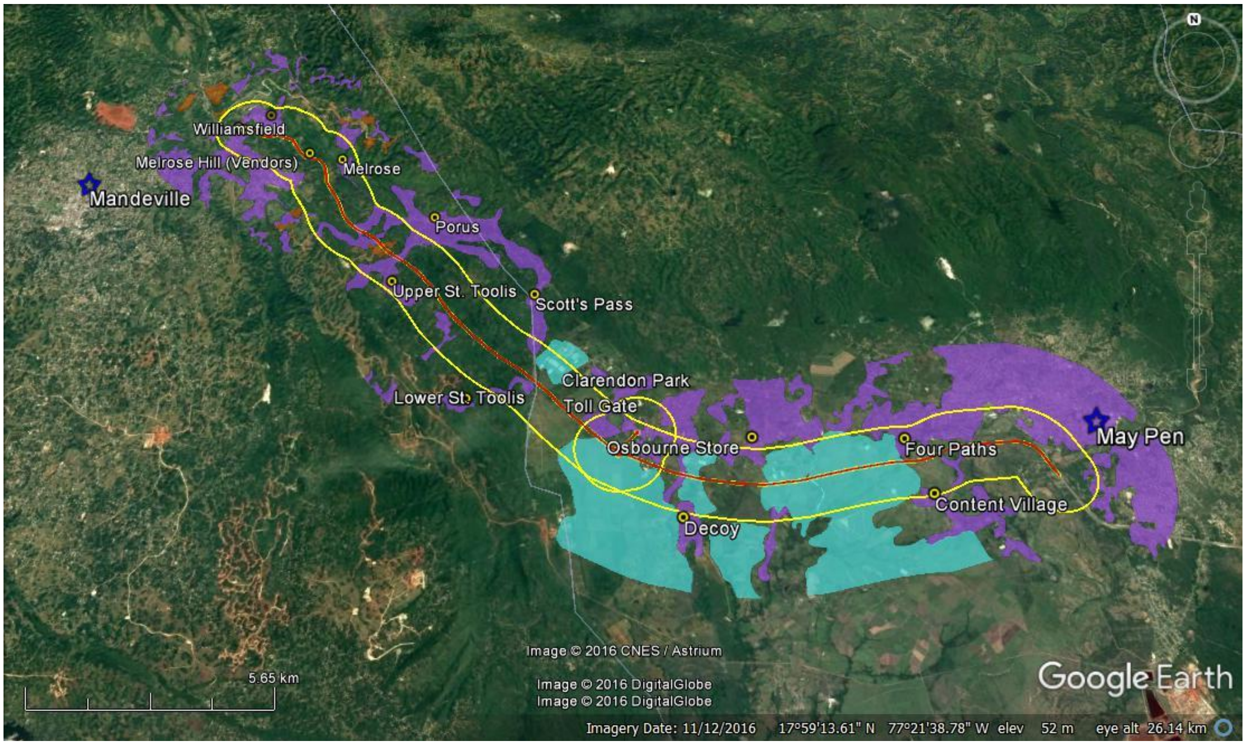


Figure 4.77: Map showing Land Use in relation to the proposed Alignment. Yellow line indicates the 1km Buffer around the proposed Alignment. Purple = residential, Blue = agricultural, Brown = mining

2km Buffer Zone

The population contributed by this zone is estimated to be approximately 30,000 and represents 38% of the population contained within all three buffer zones. The cumulative population of zone 1 and 2 is approximately 45,400. In Clarendon, this population is accounted for by approximately 50% of May Pen, that includes all of Content Village, Four Paths, Osborne Store, Decoy, Toll Gate, most of Clarendon Park and portions of Scott's Pass. In Manchester, it is inclusive of Lower St. Toolis, Upper St. Toolis, most of Porus and all of Melrose, Hope Village, Royal Flats/Williamsfield Gardens and Williamsfield.

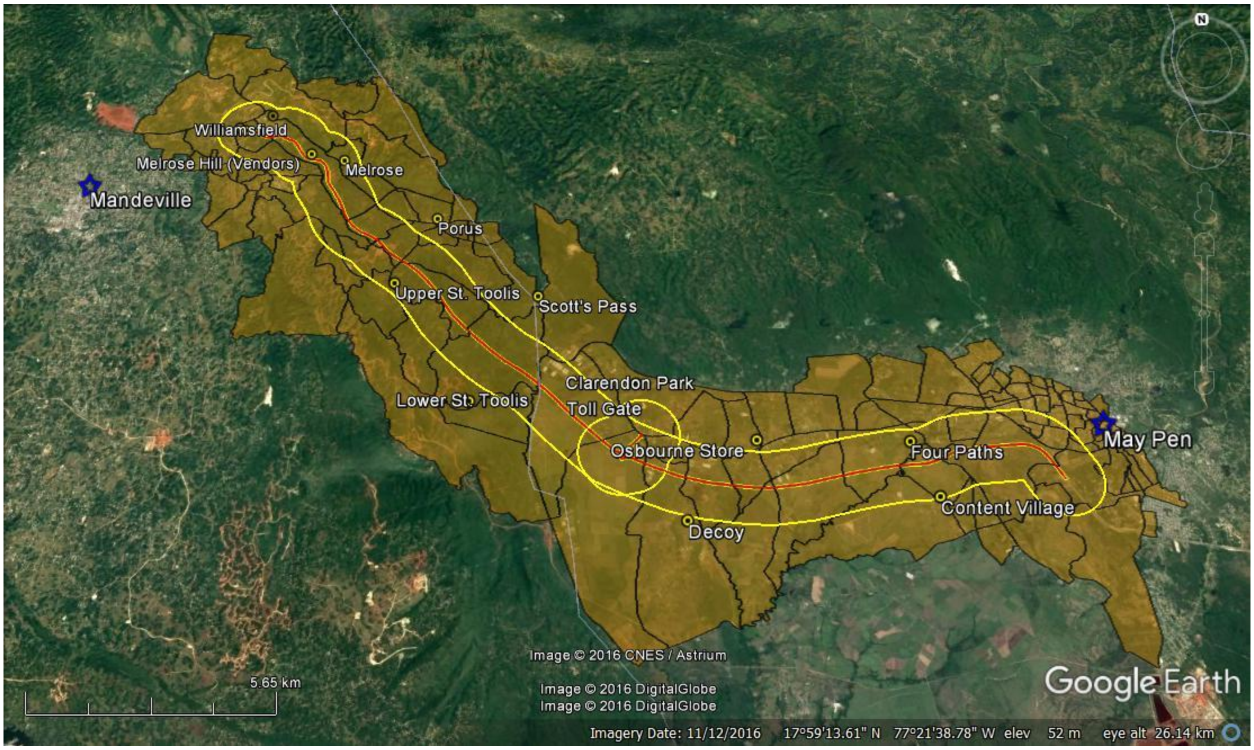


Figure 4.78: Map showing Location of Communities surveyed in relation to the proposed Alignment. Orange Sections represent those Enumeration Districts that are impacted within a 2km Buffer around the Alignment. The estimated total Population of those impacted within a 2km Buffer is 45,400.

In Clarendon, when the buffer zone is extended to 2km the pattern of land use shifts. Agriculture is no longer the main land use, but takes up approximately the same area as residential. Higher proportions of the communities of interest now fall within this buffer zone. Because the main A1 road from Mandeville to May Pen passes though larger sections of this zone, commercial activity (mainly vending and shopkeeping) is commensurately more important. Another pattern revealed is the land use to the north of the proposed alignment, which is predominantly residential, whereas to the south, it is predominantly agricultural.

For Manchester, the inclusion of the 2km buffer zone results in little change in the pattern of land use. Similarly, unutilized land and land under settlement maintain about the same proportionate share as in the 1km zone.

Almost all of the mining activity in the wider 3km zone takes place in the 2km zone. Residential land use increases towards Mandeville.

This buffer zone now incorporates almost the entire existing A1 main road including a large section of Porus and its vending activity.

No large-scale agricultural land use was observed although small-scale farming is an important activity.

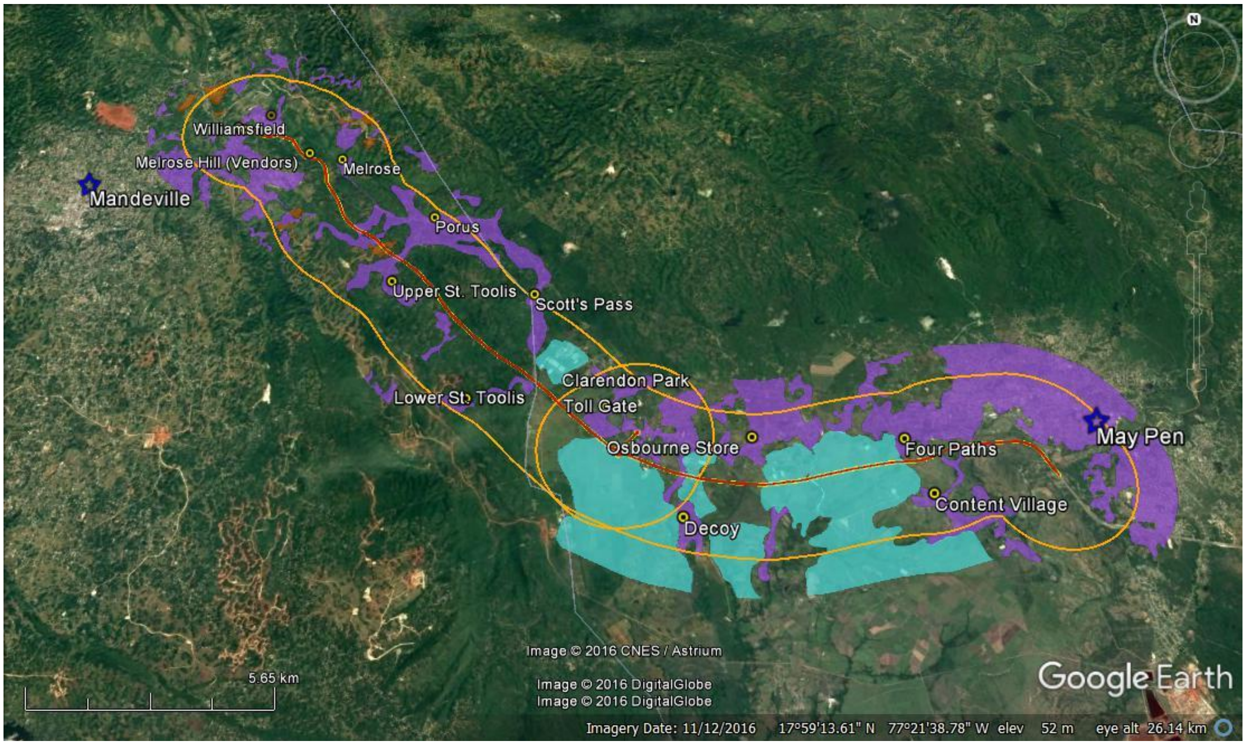


Figure 4.79: Map showing Land Use in relation to the proposed Alignment. Orange lines indicate the 2km Buffer around the proposed Alignment. Purple = residential, Blue = agricultural, Brown = mining

3km Buffer Zone

The population contributed by this zone is estimated to be approximately 33,000 and represents 42% of the population contained within all three buffer zones. The cumulative population of buffer zones 1, 2 and 3 is approximately 78,400. In Clarendon, this total population is accounted for by the greater part of May Pen, and all of the other communities mentioned in Clarendon. In Manchester, it is also inclusive of all of the listed communities, but also a small section of eastern Mandeville.

This higher proportion of population is explained by the inclusion of sections of May Pen and Mandeville, representing high-density population centres.

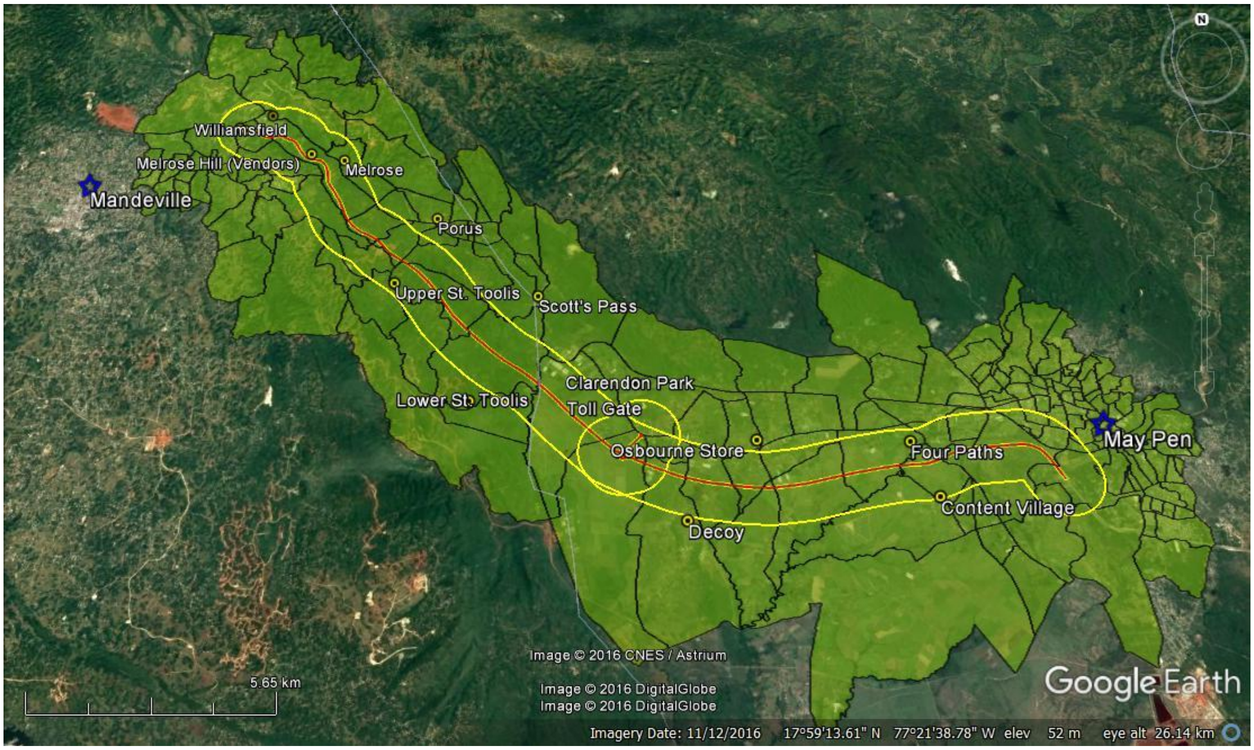


Figure 4.80: Map showing Location of Communities surveyed in relation to the proposed Alignment. Green Sections represent those Enumeration Districts that are impacted within a 3km Buffer around the Alignment. The estimated total Population of those impacted within a 3km Buffer is 78,200.

In Clarendon, when the buffer zone is extended to 3km, land use within the 1km extension shows no unique features that set it apart from the land use patterns found in the previous zones. Along the direction of the alignment, the broad agricultural and unutilized land belts are periodically broken by residential and commercial communities.

The 3km buffer itself represents a boundary beyond which two features are notable. To the north of the buffer zone, the residential and agricultural densities become much lower due to the presence of the Mocho Mountains bordering Four Paths to Toll Gate. To the south, the 3km buffer begins the transition of land use away from residential to agricultural use, as the large sugar estates of Southern Clarendon are approached. The exception to this generalized description is that residential land use expands to the east of the starting point of the alignment, to include all of Central May Pen and some outlying districts.

For Manchester, the inclusion of the 3km buffer zone results in a shift towards the inclusion of bauxite reserves. Also, residential and commercial land use, gives way to unutilized land. The western end of the buffer zone includes the north eastern section of Mandeville.

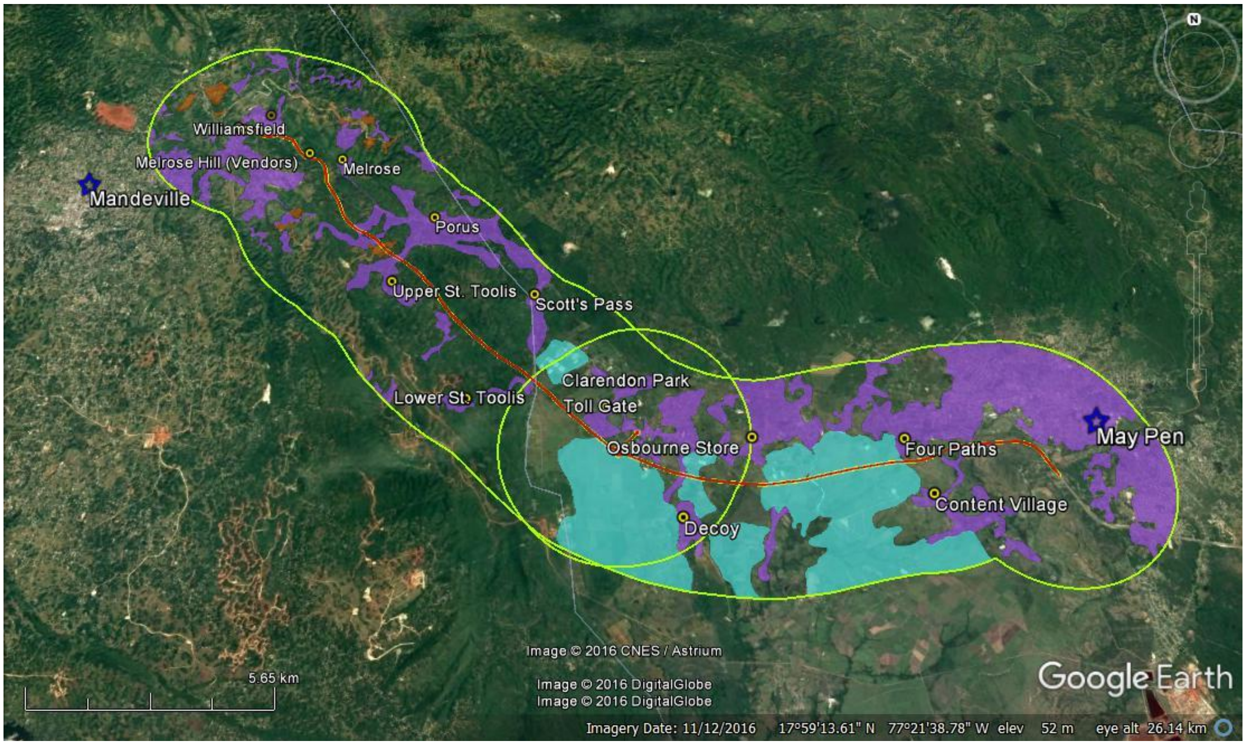


Figure 4.81: Map showing Land Use in relation to the proposed Alignment. Green lines indicate the 3km Buffer around the proposed Alignment. Purple = residential, Blue = agricultural, Brown =mining

4.3.4 Economic Activity and Livelihood within the Buffer Zones

The buffer zones can be viewed as boundaries within which economic activities take place and define general zones within which any benefits of the highway to communities adjacent to it will be experienced. Understanding these economic benefits and how they are likely to be distributed among the zones are key considerations.

The starting point for this analysis is the ranking of overall community economic activity by the 300 respondents in the rapid appraisal survey.

Table 4.14: Most Frequently Ranked Economic Activity by Community Members

Respondents = 300	1st Ranked	2nd Ranked	3rd Ranked
Community Members	Agricultural	Retailing	Entertainment & Micro services
Business Persons	Agriculture	Retailing	Micro services

1. The highway is expected to improve the transportation

The highway is expected to improve the transportation of produce from the hinterlands of both parishes to main regional markets. Currently, at the intersection of the Melrose Bypass and the old road to Porus at the Porus end, an active and significant agricultural commodities exchange market has developed.

Goods from as far away as Westmorland and St Elizabeth are 'transhipped' or sold to vendors who then transports it to other parish capitals including Kingston. The highway will facilitate some percentage of this trade, which is developing to become a two-way exchange.

A primary objective of the highway is to create travel time savings. The highway will contribute to the export/import of more cultural exchanges in a context in which community members identify entertainment as an important income source.

Increase employment opportunities by widening the labour market catchment area.

The main economic activities along the alignment can be generally characterized as:

4. Business operations (small and medium mainly, but including a few large) covering sectors such as food and clothing retail, labouring including farm labour, entertainment, mining and transport;
5. "Higglering" and hustling;
6. Professional services.

Core economic activities as in 1 and 2 above, and income generation reflect a fairly consistent pattern as between parallel buffer zones. Meaning these activities can be found in each buffer zone although food and clothing retail operations, entertainment and transport are found concentrated in those EDs through which both the proposed alignment and the current A1 road runs. These activities are more dispersed on the Clarendon plains and food and clothing retail operations more concentrated along the existing A1 roadways in the Manchester hills. Along the longitudinal axis, meaning between May Pen and Williamsfield, income activity, outside of communities such as Osborne Store, Clarendon Park, Porus and Williamsfield are much smaller in scale and support lower employment numbers as the alignment moves from Clarendon into Manchester (Figure 4.82). Labouring is mainly found in building and construction, and artisanal skills and hustling are found in all communities.

Figure 4.82: Higher income home located in the Clarendon Park area

The characteristics of these communities were based on a combination of observational tours made by the Consultants, statistical databases, discussions with parish councillors for several of the communities involved and most importantly, on a survey of community members themselves.

All communities have a blend of lower-income groups and middle-income groups irrespective of which groups comprise their majority populations.

Affluence is mainly reflected in select communities such as Royal Flats and Williamsfield Gardens.

Hope Village by virtue of its major upscale housing development would have the highest ratio of middle-income households among the communities.

Similarly, Melrose Hill vending community would represent a community grouping almost totally invested in vending.

Typically, all communities have evolved with little planning inputs other than the sometimes required building codes approval. Many building additions escape this requirement. Hope Village Royal Flats and Williamsfield Gardens are the exception as they are planned housing developments. In the remaining communities unplanned features appear to dominate.

4.3.5 Use of Alternate Road (Old Melrose Hill Road)

The consultants observed the road condition on the old Melrose Hill road to be fair. The old road would require widening, straightening, and resurfacing to be navigated safely by the current Melrose Bypass traffic load. In parts, some cutting back of rock overhangs and vegetation will need to be considered.

Street lights and road signage will also need to be considered along this stretch, particularly in the vicinity of built areas such as Melrose. It can be expected that for the duration of the construction period, vending activities will be initiated along the diversion on the old Melrose Hill road. Such economic benefit, as it brings to Melrose in particular, would need to be weighed against safety issues given the relatively poor condition of the road.

The rapid appraisal survey conducted in Melrose determined that a significant proportion of those community members sampled approved of the highway and thought it was necessary. However, business members sampled in the same area had a contrary view and the majority felt that it was unnecessary and would result in a reduction of business.

Figure 4.83: The intended temporary detour down Melrose hill during highway construction. This is also the old road Williamsfield to Porus through Melrose

Figure 4.84: Community of Melrose, looking toward the current Melrose Bypass and Proposed Alignment

4.3.5.1 Public Access

The Melrose Bypass is currently not tolled, and as such, bringing this stretch of highway under the tolled system might meet with resistance from the motoring public. The consultants did not have an opportunity to assess public sentiment on this issue, and will await the public meetings to gauge the level of concern on this issue.

4.3.6 Planned Development Activities

Based on the interviews conducted, there appears to be no major developments planned for the sections of Clarendon that the highway alignment will impact. In Manchester, however, a number of projects were highlighted. These include development in and around the Broadleaf community which lies within the 2km buffer zone of the alignment, to the southwest of Porus. This area is also near to bauxite mining zones, and is slated for residential development through JAMALCO, as well as part of a NWC project to realign a distribution pipe from Porus to Mandeville through Broadleaf. In addition to this, a 1,000-acre mixed commercial and residential National Housing Trust (NHT) development is slated for the area Mount Nelson into New Hall. Also mentioned were plans to develop the current Melrose Yam Stop into a Tourism Product Development Company (TPDCo) Rest Stop. It is not clear whether these developments will impact the alignment.

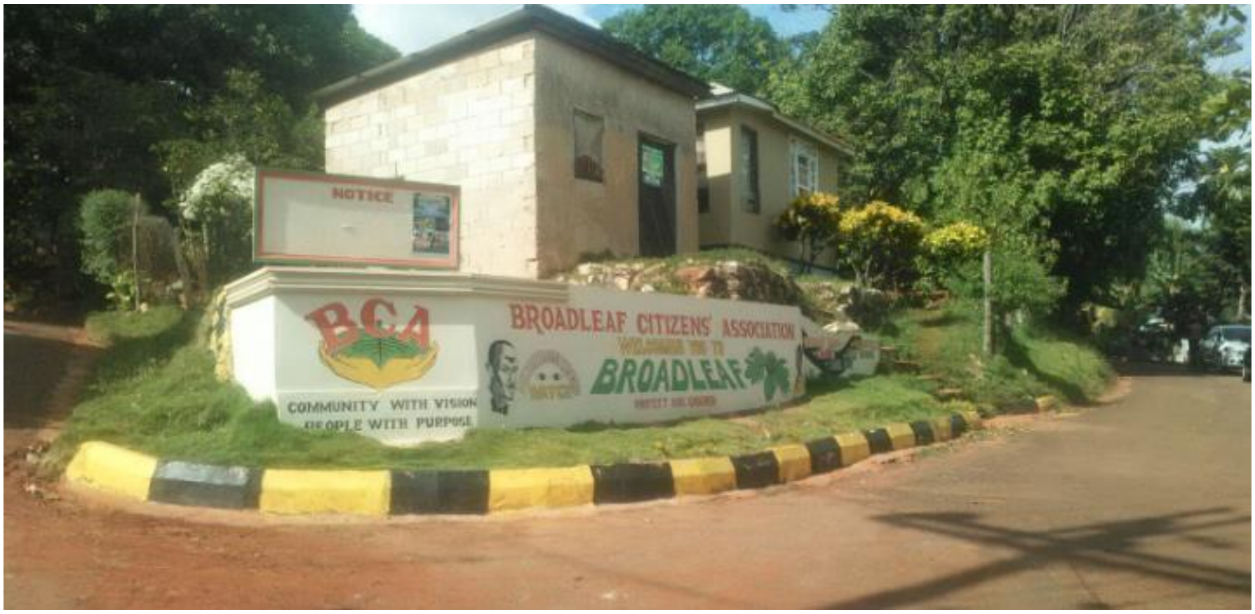


Figure 4.85: Broadleaf, site of some proposed developments including redistribution of NWC pipeline and JAMALCO residential and commercial development.

4.3.7 Squatting and Resettlement

Although most communities within the 3Km buffer zones suffer from some degree of poor housing stock, traditional squatter-type communities are absent. An important feature of the adjustments made to the original alignment for this 2C phase is that resettlement issues have been minimized. Whereas in the 2007 EIA, it was reported that some 120 structures would be impacted, the numbers currently available from NROCC are closer to 30. NROCC is to make available to the Consultants the final list of impacted buildings. They are shortly to engage in negotiations with affected property owners.

An important consideration in highway development is the impact of the roadway on pre-existing roadways, rights of way and field crossings. The Consultants were able to do a high degree of due diligence through ground verification of the alignment, to satisfy themselves that adequate provision had been made for crossing the alignment.

Table 4.15: Findings Re Alignment and Overpasses

Chainage (Km's)	Structure	General Area	Restraints to free & fair Movement	
K44–K45	1 Bridge	May Pen Bride	No Issues	
K45–46	1 Overpass	Denbigh	No Issues	
K46–K47	1 Bridge	Four Paths	No Issue	
K47–K48	2 Overpasses 1 bridge	Four Paths/Content Village	No Issue	The removal of 1 crossing between K47 and K53 would be
K48–K49	2 Overpasses, 1	Four Paths	No Issue	

Chainage (Km's)	Structure	General Area	Restraints to free & fair Movement	
	bridge	Content Village		acceptable.
K49 – K50	3 Overpasses		No Issue	
K50-K51	1 Overpass		No issue	
K51–K52	1 Overpass	Osborne Store	No Issue	
K52–K53	4 Overpasses	Osborne Store	No Issue	
K53–K54	2 Overpasses	Osborne Store	No Issues	
K54–K55	5 Overpasses		No Issues	
K55–K56	2 Overpasses	Toll Gate	No Issues	
K56–K57	2 Overpasses, 1 Interchange	Toll Gate	No Issues	
K57–K58	3 Overpasses	Toll Gate	No Issues	
K58–K59	2 Overpasses		No Issues	
K59–K60	1 Overpass	Scott's Pass	Beginning of Potential Issues	Beginning of a 3KM stretch without crossing
K60–K61	No crossing	Scott's Pass	Potential Issues	Very difficult terrain, but some justification required as impacted pathway route or structure may be present
K61–K62	No Crossing	Scott's Pass	End of Potential Issues	
K62–K63	1 Overpass	Upper St. Toolis	Potential Issues	Existing road will need to be rerouted out of alignment.
K63–K64	1 Overpass	Redberry	No issues	
K64–K65	1 Overpass, 1 bridge	Redberry	No issue	
K65–K66	1 Overpass 1 Bridge		No Issues	
K66–K67	1 bridge		Potential Issues	Existing road may need to be rerouted.
K66–K68	No crossing		No Issues	
K68–K69	No crossing		No Issues	
K69–K70	No crossing		No Issues	
K70-K71	No crossing		No Issue	
K71–K72	No crossing	Williamsfield	No issue	

Field Connectors are integrally related to ownership boundaries. This is because an overpass may facilitate only one of adjoining properties, unlike roadways which are public rights of way. The Consultants did not have sufficient cadastral information to do more than come to the general opinion, that on the Clarendon plains, land holdings are fairly large and the frequency of overpasses seems to accommodate crop movement along a network of pre-existing farm roads. In the Manchester Hills where farm holdings are generally smaller, the potential for conflict exists. NROCC and bauxite mining interests are in ongoing discussions, which will presumably resolve any issues relating to mining rights.

Some of these issues have traditionally arisen at the Public Consultation and will therefore be reported on in the final report.

4.3.8 Community Characteristics

The main purpose of the socioeconomic component of this EIA is to discern the impact of the project on the near communities and the likely impact of the near communities on the project.

As a general opinion, the Consultants expect that the impacts of the project will mainly be experienced by the communities and the communities will have very little impact on the project.

Further, it serves no special purpose to describe these impacts on a community by community basis. Where a particular impact is centered on or of special significance to a specific community, this will be highlighted. The approach adopted is to start with Table 4.16 which captures general community characteristics and then address the commonality of impacts that the highway may have on these communities and the special impacts that some communities may experience.

Table 4.16: Important Characteristics of Near Communities

Communities	Income Profile Upper Middle &Lower Income	Type of Community	Main Economic Activity	Developments Underway (that would impact the highway)	Community Perception of Social Infrastructure	Reported State of Unemployment	Perception that Community Pop is Growing	Community Approval of Project See below for business responses
Content Village	M & L	Unplanned	Other micro	Non Reported	Adequate	Very high	Growing	Approve
Four Paths	M & L	Unplanned	Retailing	Non Reported	Good	High	Growing	Approve
Osborne Store	M & L	Unplanned	Retailing & Micro Services	Non Reported	Adequate	Very High	Don't know	Approve
Clarendon Park	U M L	Mixed	Agricultural Production & Hustling	Non Reported	Good	Very high	Not growing	Approve
Decoy	M & L	Unplanned	Agricultural Production	Non reported	Poor except water	High	Growing	Approve
Scott's Pass	M & L	Unplanned	Retailing	Non reported	Adequate	Very high	Growing	Approve
St. Toolis Lower	M & L	Unplanned	Agricultural Production	Jamaica Mining in Top Hill reported	Water good Health poor	Very High	Growing	Approve
Porus	M & L	Mixed	Entertainment	Non Reported	Adequate	Very high	Growing	Approve
St. Toolis Upper	M & L	Unplanned	Agricultural Production	Non Reported	Good	High	Growing	Approve
Melrose Hill (Vendors)	L	Planned	Retailing Agro Products	TPDCO's plan for developing the site	Not asked	Not asked	Not asked	Negative impact But slight majority approve of highway
Royal Flats/ Willamsfield Gds	U & M	Planned	A few Micro Services	Non Reported	Adequate	Low	Growing	Highly approve
Williamsfield	U M L	Unplanned	Agricultural	Non Reported	Good	Not very high	Growing	Highly approve

Communities	**Income Profile** **Upper Middle &Lower Income**	**Type of Community**	**Main Economic Activity**	**Developments Underway (that would impact the highway)**	**Community Perception of Social Infrastructure**	**Reported State of Unemployment**	**Perception that Community Pop is Growing**	**Community Approval of Project See below for business responses**
Hope Village	M	Planned	Micro Services	Non Reported	Good	Not very high	Growing	Approve
Melrose	M L	Unplanned	Retailing	Non reported	Adequate	Very high	Not Growing	Approve

**Compiled on the basis of the Consultant's observations and the Community rapid appraisal survey*

4.3.9 Summary of Important Characteristics of Near Communities

The project is linear, and traverses a significant length of Clarendon and almost half the length of Manchester as measured along the A1 main road. It therefore passes close to a number of settlements that are unique in specific ways, but fairly typical across a variety of characteristics. A cursory inspection of Table 4.16 reflects that they share a number of common features.

They are mainly middle- and lower-income earning communities. Their main income source derives from retailing activities and agricultural production. Also, micro services were defined to include household skills, building skills, community services such as personal care services, and labouring. To the extent that main sectors are important sources of employment, these would be sugar estates and bauxite, across parish lines. The communities are unplanned in any formal sense though they do come under some planning interventions and regulation by local authorities.

4.3.10 Perceptions by Communities

Near communities perceptions of themselves is also fairly consistent. With one exception, their populations are all seen as growing. In the very high majority of communities, unemployment is characterized as high or very high. Social services are mainly described as adequate or good, but many communities pointed to poor service in specific instances.

Community members' approval of the project was consistent and favourable, although every community had its dissidents.

Because approximately 30% of the survey design was directed at businesses, certain responses in Table 4.16 were only solicited from this group. There was only one business operator who identified an upcoming project likely to impact the highway, and that was proposed bauxite mining activities in Top Hill Manchester. However, yam vendors at Melrose were also of the opinion that a conflict in planning existed with the highway in relation to TDPCO's own approved plan for the development of the yam park as a rest stop.

In Table 4.16, the approval rating for the project was reported for the general community membership. The opinions sought were slightly different for business operators and their responses were as follows:

81% of business operators thought the highway necessary. 80% personally supported it and 20% were against it. However, only 25% of business operators thought that the highway would have a positive impact on businesses. Whereas 43% thought that the impact would be negative and 32% felt they did not know. The main reason given by non-approvers was loss of sales.

4.3.11 Public Health and Community Health and Safety

Waste management services are provided by the MPM Waste Management Limited in Clarendon and SPM Waste Management Limited in Manchester. They serve all of the near communities.

These communities are also served by a limited number of health centres. Several health centre the needs of the listed communities in Clarendon as well as one Type B Regional Hospital. In Manchester, the communities are served by one Health Centre in Porus and one Type B Regional Hospital in Mandeville.

4.3.12 Cultural Aspirations and Attitudes

This was probed in all communities using the rapid appraisal survey. Its importance was to discern the likely link between the aspirations and attitudes of community members, howsoever motivated to the opportunities associated with easier mobility that the highway will offer. Since induced economic growth and development are important objectives of the H2K programme; the assumption to be tested is that community members are motivated to be responsive to the potential for entrepreneurship in particular.

When tabulated, the 3 responses most frequently ranked were:

1. the desire for improved employment opportunities:
2. an increase in personal income: and
3. the desire that their community achieve prosperity.

These aspirations and attitudes would be a prerequisite for taking advantage of the highway.

4.3.13 Heritage

Archaeological and historical records indicate that the project area within the vicinity of the proposed highway contains sites dating back to the Taino and the Spanish period. The subsections below elaborate on heritage features of note within the 2km buffer zone only. Heritage features outside of this area are not considered critical due to distance and impacts are not likely based on the nature of the development. Outside of these above-ground features, it is important to note that heritage elements can also exist underground and as such, during excavation, it is likely that old relics may be found. Section 6.1 elaborates further on potential impacts during the construction phase of this development.

4.3.13.1Four Paths to Toll Gate (including Clarendon Park)

The British are well represented within the 2km buffer zone of the project area with several sugar estates dating back to the 18th century at such places as Clarendon Park and St. Jago. During slavery, these estates had great houses and villages for the enslaved. In 1824, St. Jago Estate and Pen had 327 enslaved persons. The highway alignment runs though these old estates, but the above-ground historical features of these estates were not located within the alignment, but within the 2km buffer zone from the alignment. There are possibilities of relics being found underground, however, these could only be identified during excavation.

Figure 4.86 below shows the location of the St. Jago Sugar Estate. The highway will pass north of where the old sugar works exist and will pass through the community of Decoy and through old sugarcane plantation lands just south of the populated community of Toll Gate. These sugar estates would have remained under continuous cultivation well into the late 20th century. Importantly, the highway will pass through significant sugarcane lands, some of which were recently under production.

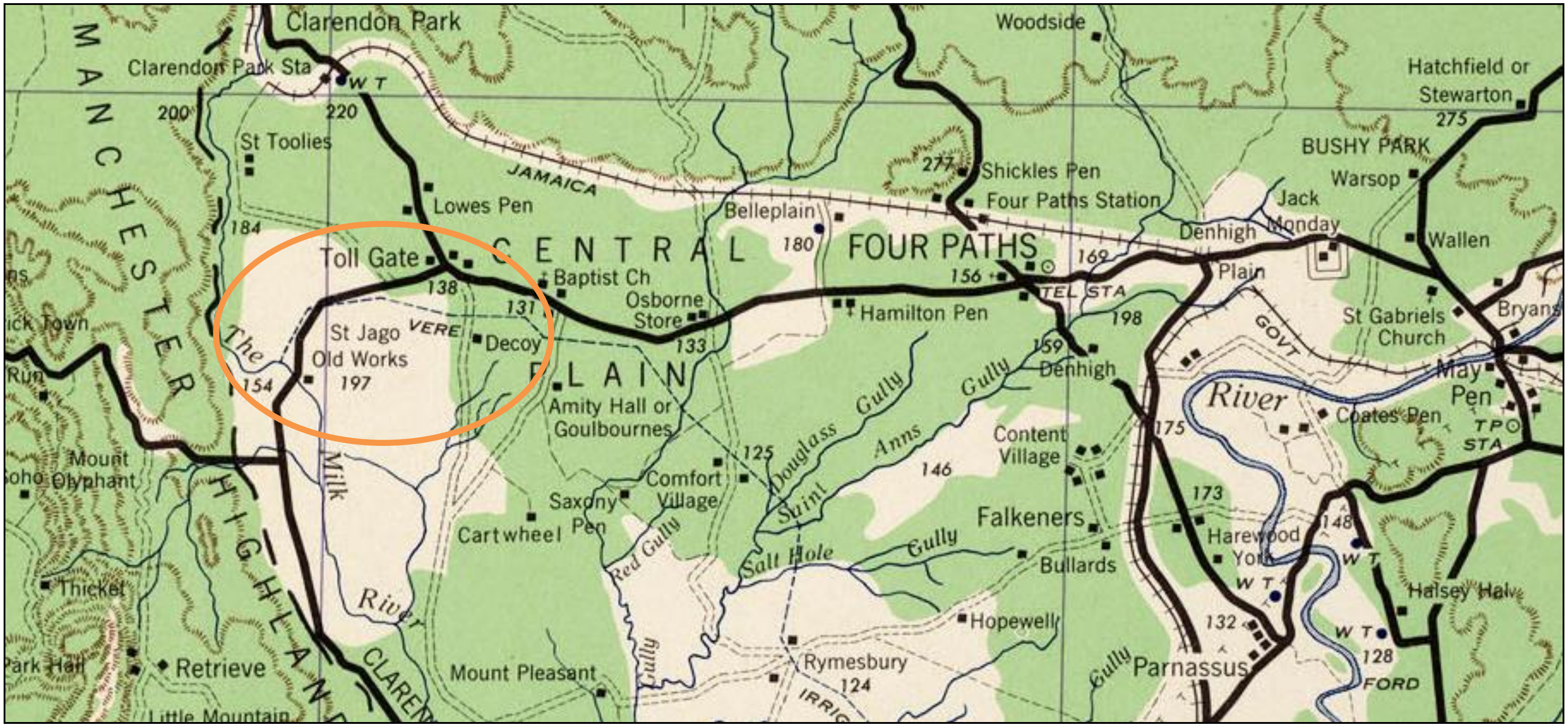


Figure 4.86: Map of Jamaica (Modified from Map of Jamaica 1944, Scale – 1:1250000)

The Four Paths Railway Station is another key heritage feature located within the 2km buffer zone, north of the alignment. The Four Paths Railway Station is a two-storey concrete building. O-n the lower level is a corridor with a colonnade and staircase leading up to the Station Master's quarters. The building has a combination of aluminium louvre and sash windows along with solid recessed panel timber doors. A zinc hip roof with an adjoining zinc shed roof covers the Station Master's quarters and balcony. The Four Paths Station is believed to have been constructed in the early 1900s (JNHT, 2016).

Figure 4.87 below shows railway stations which are key heritage features. Apart from the Four Paths Railway Station, the railway runs through Porus, Clarendon Park and Williamsfield and there is a railway station at WIlliamsfield which is within the 2km buffer zone of the highway alignment. This is elaborated on in Section 5.3.12.3.

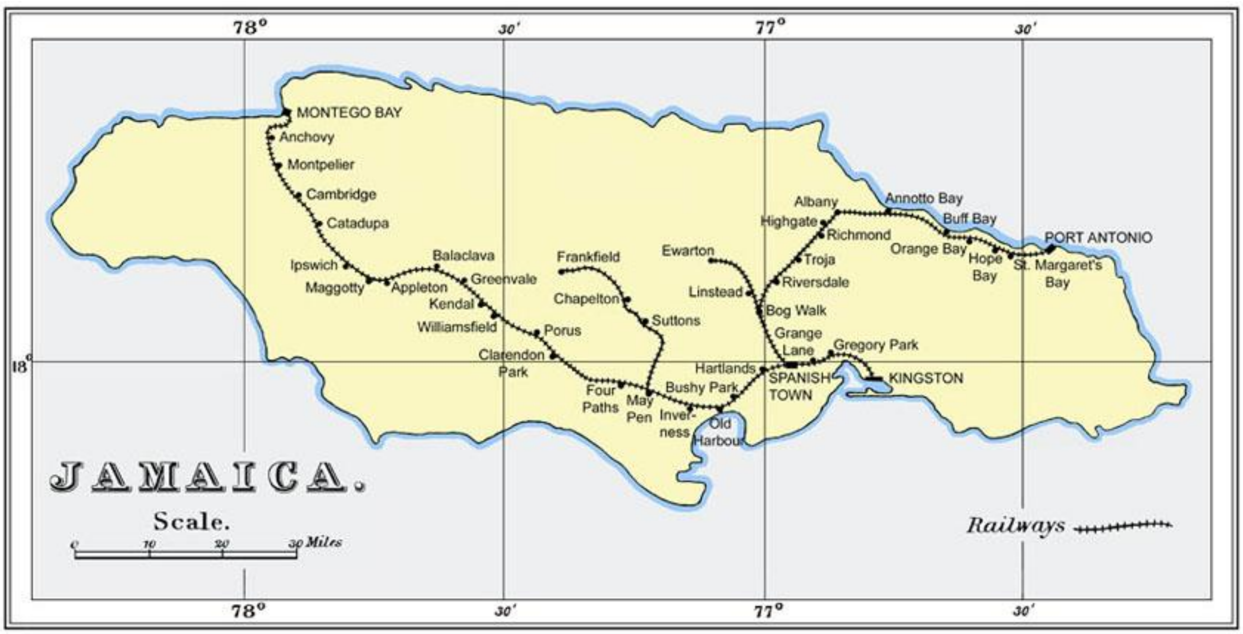


Figure 4.87: The Jamaican Government Railway in 1925 (Source: Keith Moh, Jamaica Railway)

4.3.13.2 St. Toolis to Porus

Historical records show that there was a Taino settlement located in Porus just south of where the railway line currently runs (Figure 4.88). However, relics of such were not evident during the site assessment. Additionally, this settlement is not located within the current alignment.

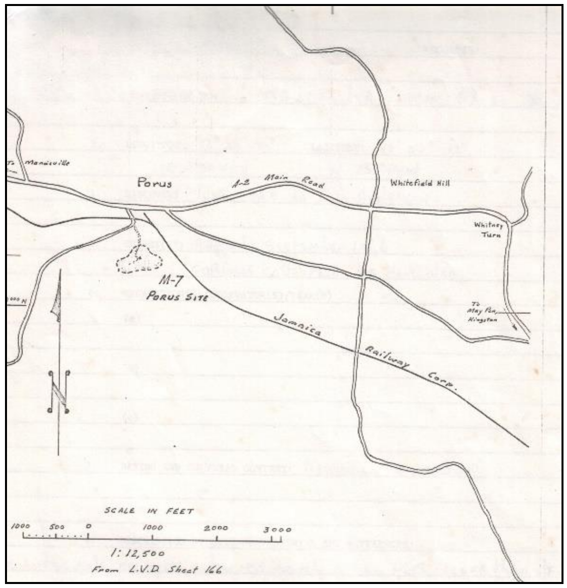


Figure 4.88: Taino Settlement in Porus (Source: Jamaica National Heritage Trust)

Site visits revealed the existence of old heritage structures within the Upper St. Toolis area. These structures date back to the post-slavery era of the early 1900s. An old sugarcane estate is also located in the St. Toolis area and in 1824, St. Toolis had 202 enslaved persons.

Figure 4.89 shows the presence of old heritage structures likely constructed in the very early 1900s.

Figure 4.89: Older Heritage Structures along the Train Line in Upper St. Toolis

Also, within the St. Toolis area are wattle and daub structures, which are no longer frequently found in Jamaica (Figure 4.90). Wattle and daub was often used to make the cramped housing space provided to enslaved persons during slavery. The structure was often constructed with one window and one door, therefore this meant that very little other than sleeping took place indoors. Life, as in Africa, was lived communally, outside (Brathwaite, 1971, p. 233–4). Post- slavery and even during the early 1900s, some settlements were still made of such material, since it was one of the more affordable options for the poor.

Figure 4.90: Wattle and Daub Structure in Upper St. Toolis

The train line, which runs across Trinity Road in Porus is located within 1km of the alignment (Figure 4.91).

Figure 4.91: Train Line in Porus

4.3.13.3Melrose to Williamsfield

Many pens were established for the rearing of cattle, for example, in the Lime Savanna at Melrose and Hope Pen in Manchester. During slavery, these pens had great houses and slave villages. The 1910 Jamaican directory shows that Melrose Pen was owned and occupied by Mr. Olgilve James. The 1910 and 1878 records show that the Hope Pen was owned and occupied by R. B. Braham and the Williamsfield Pen was owned by Heron Fanny and occupied by Heron George. These areas are within the proposed alignment, but no specific aboveground features were identified within the footprints of the alignment.

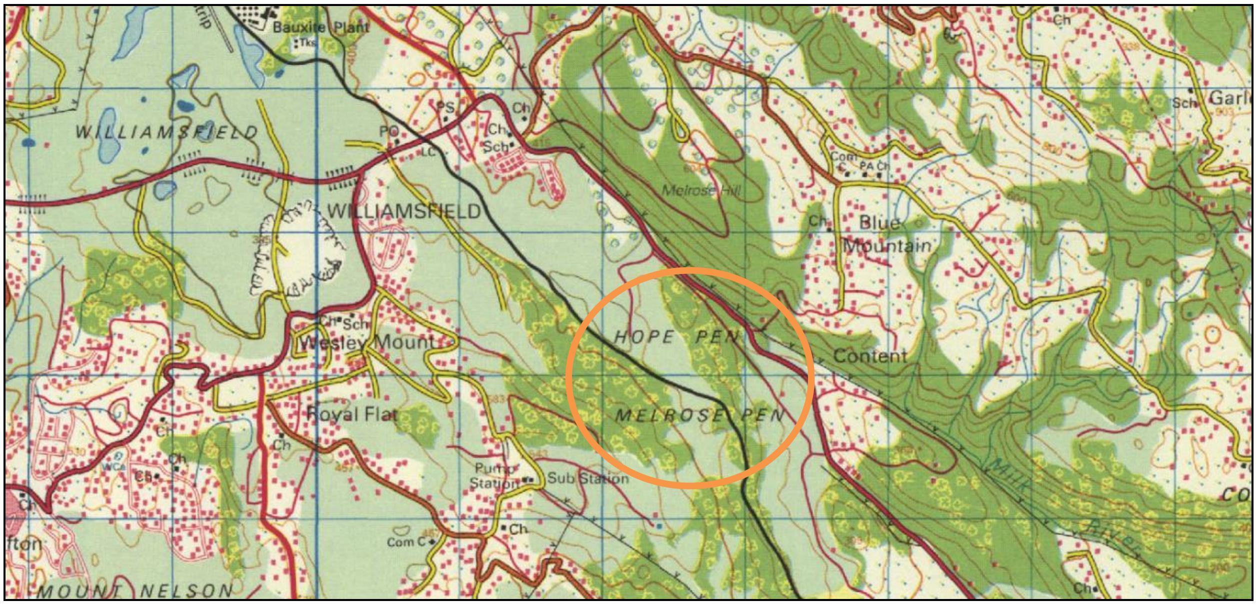


Figure 4.92: Topography Map of Jamaica showing Hope Pen and Melrose Pen, 1982 (Scale – 1:50,000)

Additionally, the Williamsfield Railway Station was constructed around 1891 and has elements of the Jamaica/Georgian architectural style (JNHT, 2016). The structure features a gable end zinc roof and timber posts each having a concrete base and finger-like timber brackets that help to support the roof (Figure 4.93). Sash windows, aluminium louvres and solid timber doors are used throughout the structure (JNHT, 2016). This feature is located within the 2km buffer zone of the alignment.

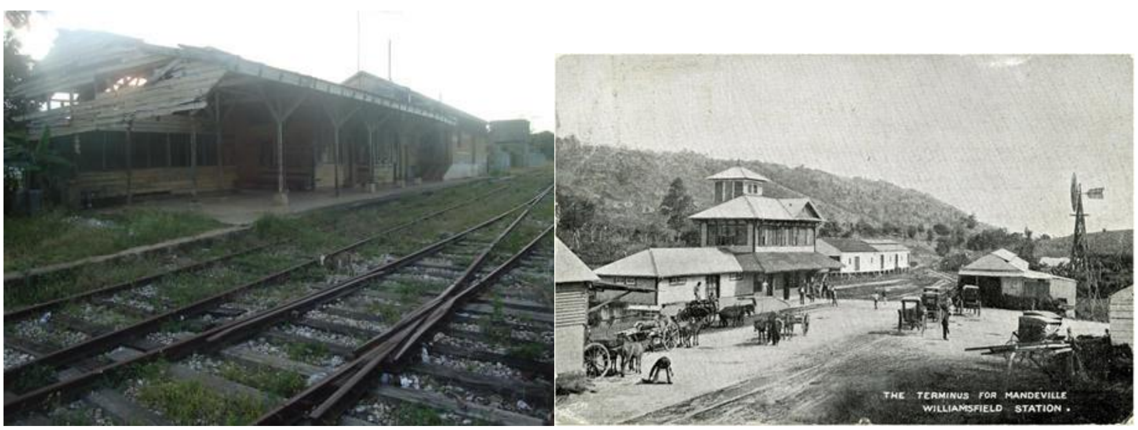


Figure 4.93: Williamsfield Railway Station (right: 1905; left: 2000) (Source: Keith Moh, Jamaica Railway)

4.3.13.4Summary

There are distinct heritage features near the alignment, but few of these above ground actually exist within the 2km buffer zone from the alignment and no above-ground elements were identified within the path of the alignment. Underground relics may exist due to the presence of slave villages and so protection of any artefacts found during excavation would be critical.

5 IDENTIFICATION OF IMPACTS AND MITIGATION MEASURES

This Section presents the potential impacts and recommended mitigation measures, where necessary, during the construction and operation of the proposed highway Phase 1C May Pen to Williamsfield.

5.1 Construction Phase – Impacts and Mitigation

Potential physical, biological and socioeconomic impacts during the construction of the highway are presented in Sections 5.1.1 to 5.1.3 respectively. Those impacts deemed to be negative, mitigation measures have been recommended.

5.1.1 Physical – Impacts and Mitigation

5.1.1.1 Mineral Resource/Construction Material – Impacts

Sand and Quarry

Aggregate is generally exploited for use in the building and construction industry. Asphaltic concrete mix for road pavement construction normally includes river aggregate as construction material. Its location close to the highway alignment makes the sourcing of this aggregate economically beneficial for the highway project. However, purchase of the river aggregate for the asphaltic mix will also depend on the quality of the material and demand and supply considerations by the highway developers.

Some of the positive impacts will include:

- Improve the economic viability to the project where material can be sourced cheaply because of proximity to the project activities. It would also imply that the need to import material from other external sources would be eliminated so that project costs can be kept to a minimum.
- Increase in employment for workers in the river aggregate industry.

Negative impacts include:

- The strong demand for river aggregate for the major highway project could create shortage of material for other stakeholders in the building and construction industry.
- Illegal quarrying could be increased because of shortage of supply to the rest of the market.

Limestone Aggregate

Limestone aggregate will be in high demand as fill for the construction of the highway.

The positive impacts are:

- A large percentage of the fill will be obtained from excavation in the hills of St. Toolis, Reeves Wood and Melrose Hill areas, thereby reducing construction waste on the project and minimizing costs.

- Material for the May Pen to Clarendon Park segment can be sourced within short distances from the construction activities, especially in the Ebony Park area where limestone deposits can be used as fill, if required.

Negative Impacts include:

- If the limestone aggregate is sourced on the northern side of the existing main road between May Pen and Clarendon Park, then it will lead to major traffic problems as haulage trucks would be crossing the main road at different points and at regular intervals to its intended destination.
- Dust pollution from haulage trucks travelling from source to project site will be a problem for communities located between the quarry or burrow areas and highway project construction site.
- The proposed alignment has been carefully designed to pass through areas that are unpopulated or underpopulated in order to minimize the impact of construction on communities. Notwithstanding, however, a small number of communities will be impacted by the movement of haulage trucks, the placement and rolling of fill for the highway. These communities will include, but are not limited to Ebony Park, Redberry and Porus, especially Hamden Road residences.

Bauxite

If the May Pen to Williamsfield Highway maintains the proposed alignment, then it will pass through a number of bauxite deposits in the mining lease area operated by the Jamaica Aluminum Company (Jamalco). Some of the deposits, particularly in Redberry and Reeves Wood, are large, extending over a wide area. It implies that bauxite in the St. Toolis and Redberry areas would be sterilized and that bauxite earnings would be lost to the country. The JBI is seeking to ensure that the highway alignment will have a minimum impact on the bauxite reserves through collaboration with the highway developers, although it expects that a few of the smaller deposits could become sterilized following the process of negotiation.

Sinkholes

The following are potential negative impacts that are likely on sinkholes during the construction of the highway.

- Potential blockage and ponding in the sinkhole areas;
- Damage to the road infrastructure from flooding;
- Prevention of stormwater to recharge the aquifer if the sinkhole functions as a recharge area.

Cut and Fill

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

Material for the May Pen to Clarendon Park section of the highway will take up a large percentage of the fill volume, which is expected to be sourced from the cut areas. Material from road excavation in the hilly terrain of St. Toolis and Reeves Wood, will be used as construction fill on the May Pen to Clarendon Park including where in Clarendon Park area where deep fill (11m–14m) for roadbed construction will be needed.

If the project requires more material, the establishment of a quarry, the necessary licenses/approvals will be sought and quarries will be identified based on the following criteria:

1) Proximity to project
2) Type of material required
3) Nature of approval from authorities

If there is any surplus, this will be managed in a safe and efficient manner based on an approved Waste Management Plan.

Landslide

Field visits and aerial photographic interpretation conducted on the highway route suggest that the project environment is generally stable with respect to landslides. The areas that show potential impacts for slope movement include:

- Landslide on the tributary of the Milk River where the land rises above the alluvial plain in the St. Toolis area;
- All areas on the highway alignment which are crossed or affected by geological faults. The areas include the Reeves Wood and Melrose Hill Bypass which are susceptible to rockfalls and slides;
- In St. Toolis where deep cuts ranging from 15m–27.9m over a distance of 1.1 Km (K59,900–K61,000) and 13m–21m for a distance of 100m (K62,800–K62,900) are to be excavated in the karst limestone.

Blasting

The potential impacts of blasting will most likely affect those communities which the alignment passes through as well as construction workers who are in close proximity to the blast sites**.** The following are the potential impacts:

- A residential dwelling located at the foot of the hill in Reeves Wood (near to K62+500) within the fault zone is likely to be impacted. This area has shown evidence of rockfalls in the past. Blasting could mobilize rocks/boulders to be detached from the slope resulting in personal injury or damage to property.

- A number of residences are located near to alignment road crossings on the southern section of the town of Porus. Although blasting will not be extensive in this area, the potential of fly rock from blasting and structural damage caused by blast vibrations could occur if proper mitigation measures are not employed to minimize these negative impacts.

- Fly rock could also be generated where front-row burden (distance between the front row blast holes and the nearest free face) is inadequate or if the stemming column too short. This has the potential to cause injury to workers on the construction site if large rock/boulders are thrown in the air during blast operations.

- A major concern is the safety of workers who operate on the construction site. The blast energy generated from excavation generally releases body and surface waves which could cause mobilization of loose limestone on the slopes.

Earthquake

Earthquake can result in several negative impacts to the general area. These are outlined below.

- Potential damage to highway structures such as bridges, overpasses and underpasses during a moderate to large earthquake;

- Ground settlement problems to road infrastructure, especially areas consisting of deep fill that are not adequately compacted to specifications;

- Potential of slope failures along unprotected embankment slopes and high road cuts, particularly in fault zones.

5.1.1.2 Mineral Resource/Construction Material – Mitigation Measures

The sourcing of mineral resources that will be used during construction also may have impacts, these issues are elaborated below.

- Manufactured sand and gravel (limestone) could be exploited by other users in the building and construction industry as an alternative to river sand/gravel if there is a shortfall on the market for sand and gravel as a result of the highway project.

- The Mines and Geology Division should aggressively monitor the activities relating to illegal sand mining in the event that there is a shortage of supply of construction material on the market.

- If required, limestone aggregate for roadbed fill application should be sourced from a quarry on the south of the highway alignment. This will prevent haulage trucks crossing the existing main road, especially between May Pen and Clarendon Park, thereby minimizing traffic interruptions on the main road.

- To reduce dust pollution during roadbed construction, wetting of the road should be done on a regular basis preferably every 30 minutes and in accordance with best practices for highway construction.

Bauxite

Bauxite deposit areas are likely to be impacted by the highway alignment. These issues and mitigation measures are presented below.

- The highway alignment should be shifted to the north east in order to avoid the larger bauxite reserves in Redberry and Reeves Wood areas.
- Where sterilization is unavoidable, Jamalco reserves the right to mine out and stockpile any deposit on the north eastern side of the alignment.
- The highway developers should ensure that access to mining on the north east of the alignment be created and not blocked by highway construction.
- Site visits should be conducted between JBI and highway developers to ensure that the best possible alignment has been arrived at that will do as little damage as possible to the bauxite reserves in the Jamalco mining lease area.

General Treatment of Sinkholes

The mitigation and treatment of any sinkhole affected by the construction of the highway will be in general terms as follows:

- Sinkholes will first be evaluated once identified in the field and the results will be presented to NEPA.
- Excavation of soft material to a depth specified by the geotechnical engineer and enlargement of the sinkhole, as necessary, to allow for installation of the filter material;
- Placement of non-woven geotextile at the bottom of excavated material and placement of boulders (100/300mm rip-rap);
- Specific detailed design information will be developed during the design of the project.

Material Surplus from Road Excavation

Road construction fill will be generated as surplus from earthworks during the construction of the highway. The following are recommended:

- Spoil tips for construction waste should be kept as close as possible to the project site and should be secured to prevent erosion;
- Where possible, surplus material should be used for landscaping purposes;

- Disposal and management of material surplus should be incorporated into the overall solid waste management plan for the project.

Landslides

Landslides are can be a negative impact during and post construction activities. These issues and mitigation measures are presented below.

- Avoid the landslide area in St. Toolis along the tributary of the Milk River during construction;
- Use benched slopes in the areas with rockfall and rockslide potential. Additionally, dynamic screens as a rockfall protection measure could be used for large boulders and net/wire mesh (Figure 5.1) for preventing smaller rock blocks (<5m diameter rocks) from being detached from slopes;
- Reduce slope angle by cutting back excavated slope for moderate to high slopes;
- Improve slope stability in areas that will require very deep excavation cuts by benching the excavated slope (Figure 5.2). The design of the benches will be based on the mechanical properties of the rock mass and this is to be determined by the geotechnical engineer;
- is Employ the construction of earth retaining walls where these are required. This is another option for improving stability.

Figure 5.1: Example of Net Mesh Construction for Rock Fall Protection

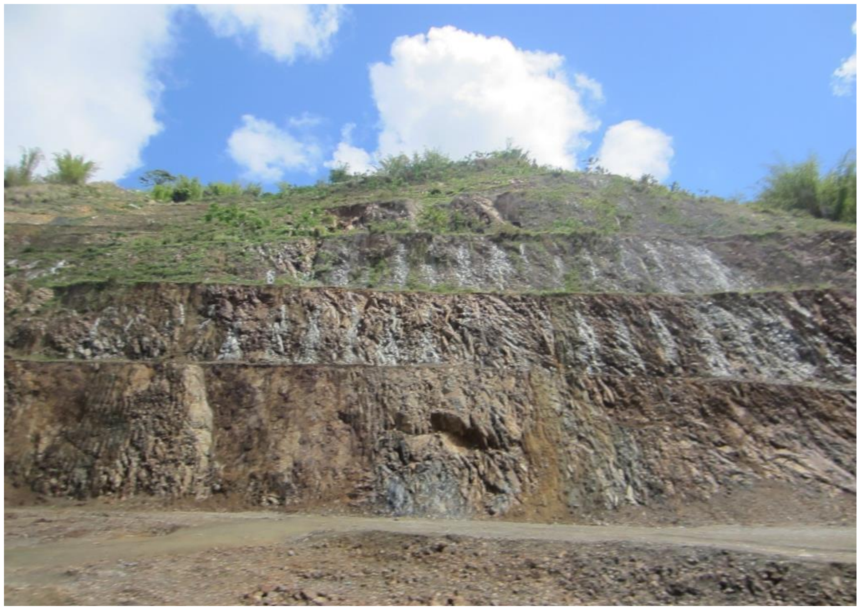


Figure 5.2: Typical Bench Slope to minimize Slope Movement, especially in deep Road Cuts

Blasting

In order to minimize the negative impacts of damage from blast operations, the following mitigation measures should be considered;

- A pre-blasting survey should be conducted prior to blast activities in areas that could be impacted by blasting;
- Peak Particle Velocity vibration should not exceed 25 mm/sec.;
- Detonation for each row of blast holes should be delayed, preferably by about 8 milliseconds;
- To reduce the occurrence of 'fly rock', stemming of the blast drill holes should be sufficiently deep so that the blast energy is dissipated mainly within the ground rather than on the aboveground surface. Where necessary, the cover blast technique must be applied;
- With respect to safety at blast sites, precautionary measures such as appropriate safety and protective gears, blast warning signs and signals and the proper control and management of blast sites are extremely important;
- Seismographs should be used where necessary to monitor each explosion as a means of control;
- An experienced blast contractor should be used and the contractor is required to have adequate insurance coverage as a prerequisite for undertaking the work.

Earthquake

Minimising issues associated with earthquake events will require consideration of the following mitigation measures.

- ✓ Highway structures should have seismic designs included as part of the design principles for the highway and in accordance with the Adopted IBC code or other international seismic codes relevant to the area.
- ✓ Rock fall/slide protection measures should be employed to minimize the impact of ground shaking on the excavated slopes within faulted zones.
- ✓ An earthquake hazard management plan should be developed as part of an overall disaster contingency plan for the highway.

Erosion and Sediment Control

<u>During Design Phase</u>

ii. Incorporate into the design appropriate nonstructural practices to prevent or minimize erosion (as well as practices or measures to mitigate other environmental impacts). The following are some of the erosion and sedimentation control considerations that should be part of the design:
    - Protecting areas that provide important water quality benefits and/or are particularly susceptible to erosion and sediment loss;
    - Limiting increases of impervious areas, except where necessary;
    - Limiting land disturbance activities such as clearing and grading to the minimum necessary. Avoiding disturbance of unstable soils or soils particularly susceptible to erosion. Where appropriate, protecting and retaining indigenous vegetation to decrease concentrated flows and to maintain hydrology;
    - Incorporating appropriate permanent features to manage runoff without causing erosion;
    - Minimizing the area of bare soil exposed at one time (phased grading);
    - Making provisions for stream crossing areas (natural and manmade);
    - Avoiding, as much as possible, alteration, modification, or destruction of natural drainage features and natural depressions (runoff storage areas) on site;
    - Designing the project so that natural buffers adjacent to coastal water bodies and their tributaries are preserved;
    - Making provisions for stabilizing cut-and-fill slopes caused by construction activities;
    - Including in the contract documents a project-specific erosion and sedimentation control plan (the plan will need to be amended after the construction contractor is selected, to fit his/her construction practices and schedule). The plan should emphasize the use of erosion controls to reduce the amount of suspended sediments along with the need for sediment controls.

iii. The Designer or the Design Project Manager, as applicable, should develop an Environmental Protection Plan incorporating all the measures or practices that are considered necessary to mitigate adverse environmental impacts. The main component of the environmental protection plan is an erosion and sedimentation control plan (ESC Plan) to control erosion and sediment and pollution problems on construction sites. The ESC Plan should generally contain the following:
   - Description of predominant soil types;
   - Details of site grading, including existing and proposed contours;
   - Design details and locations for structural controls;
   - Provisions to preserve topsoil and limit disturbance;
   - Details of temporary and permanent stabilization measures;
   - Description of the sequence of construction;
   - Provisions for monitoring implementation and performance of measures.

iv. Erosion Control

Erosion controls are used to reduce the amount of soil or sediment that is detached during construction and to prevent sediment from entering runoff. Erosion control is based on two main concepts:

   - Disturb the smallest area of land possible for the shortest period of time; and
   - Stabilize disturbed soils to prevent erosion from occurring.

v. Best Management Practices

- Schedule projects so that clearing and grading are done during the time of minimum erosion potential;
- Avoid area-wide clearance of construction sites. Clear only areas essential for construction;
- Avoid disturbing areas that are not essential for completing construction activities;
- Avoid disturbing vegetation on steep slopes or other critical areas;
- Locate potential non-point pollutant (NPP) sources such as material stockpiles, borrow areas, borrow roads away from steep slopes, water bodies and critical areas;
- Route construction traffic to avoid existing or newly planted vegetation;
- Protect natural vegetation with fencing, tree armoring, retaining walls, or tree wells;

- Stockpile good quality topsoil (taking appropriate precautions) and reapply to revegetate site;

- Cover and stabilize topsoil stockpiles to prevent erosion;

- Intercept runoff above disturbed slopes or newly seeded areas and convey it to a permanent channel or storm drain with the use of earth dikes, perimeter dikes/swales or diversions and pipe slope drains;

- On long or steep disturbed or manmade slopes, construct benches, terraces, or ditches at regular intervals to intercept runoff;

- Use retaining walls to reduce the steepness of slopes and to reduce erosion potential;

- Use check dams across swales and channels to reduce the velocity of concentrated flow and thus reduce erosion;

- Use mulch/mats for temporary protection of the soil surface or when permanent seeding is not feasible.

vi. Sediment Control Best Practices

Sediments control capture sediments that is transported in runoff. The main processes used to remove sediments from urban runoff are filtration and detention. Some of the sediment control devices for the highway may include:

- Sediment Traps – *S*ediment traps are small impoundments that allow sediment to settle out of runoff water. They are typically installed in a drainage way or other point of discharge from a disturbed area. Temporary diversions can be used to direct runoff to the sediment trap.
- Filter Fabric Fence – These fences filter sediment out of runoff as the sediment-laden runoff flows through the fabric. Filter fabric fences should be used only where there is sheet flow (no concentrated flow).
- Inlet Protection – These are barriers placed around a storm drain drop inlet to trap sediments before they enter the storm sewer system.
- Vegetated Filter Strips – Vegetated filter strips are low-gradient vegetated areas that filter overland sheet flow. Runoff must be evenly distributed across the filter strip. Level spreading devices can be used to help distribute the flow evenly across the strip.
- Grassed Swales – These are are typically shallow, vegetated, man-made ditches designed so that the bottom elevation is above the water table to allow runoff to infiltrate into the groundwater. The vegetation prevents erosion, filters sediment, and removes a limited amount of nutrients.

5.1.1.3 Hydrological Impacts

The proposed drainage criteria for the proposed highway will have a design life of 50 years. It will be designed to accommodate the 10-year flood event for most minor crossings, while the major crossing, such as the Rio Minho and Milk River, will have design consideration up to the 100-year rainfall event.

The drainage system will be designed to accommodate typical Jamaican climatic conditions, comprising heavy rainfall and rapid runoff, through a two-tier drainage system:

- The minor drainage system will collect highway runoff resulting from the more frequent storm events and convey water across the roads and is based on the sectional highway areas required to provide sufficient flow capacity with a safety-free board. The peak flows will be calculated using the Rational Method. The discharge invert of these culverts will depend largely on the ground elevation at that location and will take into consideration all local hydrological and geological constraints. Approximately 80 such culverts are anticipated.
- The major drainage system of which there are two, the Rio Minho and the Milk River, will be designed using the Jamaica 2 Method to determine the runoff hydrographs for these large catchments.

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. The minimum diameter of inlet lateral pipes shall be 300mm. The minimum soil cover over storm drain pipes at locations without traffic shall be 700mm, while that at locations with traffic, it shall be 1000mm. Ditches will be of a trapezoidal design and their size will be consistent with the calculated flow to be accommodated plus a safety freeboard. In general, all ditches will be lined; where their longitudinal gradient is greater than 3% or where in-situ material is likely to scour, concrete, riprap, grouted stone or precast concrete will be used.

During the construction phase, features such as site access, storage of materials, temporary site drainage conveyance, protection of ground surface from erosion, sedimentation and over-compaction require particular attention. To achieve an environmental balance, construction planning has to incorporate erosion and sediment control measures together with the need for reasonable maintenance inspections. However, in Jamaica construction practices and general workmanship have made the 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 critical and particularly so on a major highway corridor with numerous stakeholders.

Notwithstanding the foregoing, the alignment crosses several streams, dry gullies and gullies and rivers, therefore, 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 soil types that are more prone to hydraulic erosion and design appropriate solutions at the local level, as areas with dense drainage patterns or known historical flooding will present greater erosion hazard.

- If encountered, caves or other karst features should not be infilled; if they can be avoided, they should, as these will be active infiltration points for runoff.
- Determine temporal and permanent drainage features/pathways and define the limits of roads and drainage catchments. Minor flow ditches should be grassed, while major flow ditches should be able to handle both minor and major flows satisfactorily.
- Determine the extent of any temporary channel diversion for the existing drainage features; particular care will be required at locations that are known to flood. Scour potential will also need to be assessed, and if required, rip-rap lining or another form of suitable protection should be implemented.
- 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 minimizing the period of exposure of exposed open ground, taking particular care to plan construction in known flooding areas during low rainfall periods.
- Identify locations for topsoil or aggregate stockpiles and temporary construction roads and site camps and ensure that sediment barriers or sediment traps are constructed around such stockpiles. This will prevent sediment discharges to nearby watercourses;
- 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 construction phase. Options such as the construction of temporary earthen berms or similar grade-elevating devices should be considered.
- Identify any groundwater wells that may need to be relocated. 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 300mm beyond the outer diameter of the well. If the well cannot be relocated, then alignment modification may be an option. St. Toolis No.3 falls within 25m of the highway centreline and will require protection measure, such as access control and flooding protection, if the well will be maintained into operation of the highway and not relocated.
- Fuel storage, fuel discharge points and vehicle/machinery maintenance yards shall be located at least 100m from any minor or major water course.
- Waste disposal facilities for human, liquid and solid wastes should be self-contained and not located within 100m of any drainage pathway, depression/sinkhole or well.
- If groundwater emerges from any construction burrows, etc. during construction, then these locations should be made known to the WRA.

The objectives of the erosion controls during construction should:

- Avoid disturbing vegetation on steep slopes and limit or reduce soil erosion, sediment movement and deposition to water bodies of all land disturbing activities. This can be achieved by staging the construction and clearing only areas essential for construction. Seek to establish temporary or permanent cover as soon as possible after final grading has been completed. Surface stabilization 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 4-year construction period.

Erosion and sediment control techniques that should be considered are:

- Cover and stabilize topsoil stockpiles or other material stockpiles to prevent erosion. Small stockpiles can be covered by tarps, while larger stockpiles should be stabilized around the base by erosion blankets or a straw bale barrier.
- Upslope runoff should be intercepted and diverted away from stockpile into an adjacent natural drainage course.
- Route 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. Maintain natural vegetation as best as practicable as these areas can act as sediment sinks.
- Install gravel diversion trenches (French drains) upstream of exposed land, bearing in mind that depth to groundwater may limit vertical depth.
- Construct 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. Install 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.
- Install silt dikes and runoff ditches where appropriate to prevent silt from leaving sensitive areas (borrow sites, spoil sites, etc.) and entering farmland or water bodies. Natural slopes should be benched to slow runoff velocities.
- Use temporary groundcover (matting, grass bales, sandbags, etc.) on disturbed and exposed areas to control erosion and retard runoff, particularly during rainy periods. Install geotextiles

and erosion control fabrics in difficult areas, such as, fractured slopes or slopes with thin erodible soils.

- Locate all possible pollution sources away from steep slopes, water bodies, known flooding areas, and other hydrologically critical areas. A chemical control management plan should also be implemented.
- Provide construction and site camp roads with stabilization 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 stabilization.
- Use check dams across swales and channels to reduce the velocity of concentrated flow. Check dams should be used when a swale or channel will be used for a short time and it is not feasible or practical to line the channel or implement flow control.

Pre-Highway and Post-Highway Runoff

The highway crosses several major and minor drainage systems, however, only three main crossings were evaluated, the Rio Minho Bridge, St. Anne's Gully and Milk River and two minor crossings at Km52+380 and Km54+750.

In all cases, preconstruction flows were substantially greater than the estimated contributing runoff from the highway. Percentage changes ranged between 0% at Rio Minho, due to its significant pre-construction flows, to just under 5% at the St. Anne's Gully and a typical drainage pathway. The table below outlines the scoping pre- and post-construction runoff calculations.

In general terms, the volume of runoff created by the highway between pre- and post-development will not exceed the surface water flows from the pre-development site. An increase post-development of between 5-10% is normally deemed generally acceptable.

Given that the area has significant historical flooding issues as demonstrated by extremely deadly floods in May-June 1986, the construction of a raised highway across the alluvial plain between Milk River and the Rio Minho will become in effect become a 15km long berm obstructing surface flow even with exit points at the major and minor crossings. Without due engineering design consideration for, sheet flow, concentrated flows and the backwater flooding effects of the highways normal surface flows may become impeded along sections of the highway that cross the alluvial plain. Approximately 260-300 sq km of catchment will be contained behind the raised alignment; runoff from various catchments will easily exceed 100m^3/s for a 25yr event. Hydraulic modelling studies by Dessau-Soprin (May 2000) reported water levels behind the Rio Minho and St. Anne's Gully crossings of up to 54.5m and 45.5m respectively for the 100yr rainfall event. This backwater would extend 1km upstream at Rio Minho and about 200m upstream for St. Anne's Gully. Flemming Gully and the Milk River were not evaluated by Dessau for backwater effects (see backwater effects section below). Given the history of Clarendon Park it is highly recommended that a complete pre- and post-construction flood plain mapping be undertaken to inform the design engineers of the expected water depth post-construction that could occur with an extreme event such as the May-June 1986 floods. At a minimum the 100yr pre-development floodplain evaluation should be undertaken before construction is permitted to ensure the design engineers have appropriately considered the possible backwater baseline in such a hydrologically sensitive area and mitigation solutions are actively evaluated and incorporated within the overall design. Given that the area is hydrogeologically complex and of known high risk, the unusual case evaluation, such as the 1986 rainfall, should be analyses. One such mitigation would be the use the right of way corridor north of the highway road edge as swale/storage depression that ultimately discharges to the several crossings beneath the highway. Limiting upstream development or ensuring zero post-construction runoff from any new development within the catchment will also have to be incorporated to ensure surface runoff is controlled in the long-term. A comprehensive infrastructure development as recommended by Stanley (2012) should also be pursued and integrated with the proposed drainage solutions for the proposed highway.

However, given the perception on the ground that the highway will increase flooding, mitigation considerations should be incorporated by the design engineers to include detention structures (swales, dry wells) between the toe of the road embankment and the land acquisition limit of the highway corridor. Installation of such swales in the unused corridor can be used to intercept sheet flow and concentrated flows and safely channel these flows to designed exit points beneath the highway. If these areas are appropriately engineered, they could provide significant potential for runoff storage and provide sufficient detention capacity to reduce the quantity of water discharged to any adjacent drainage systems. Ultimately, this would provide for some level of comfort to the residents in the surrounding communities by demonstrating that every effort is being undertaken to reduce any contributing flows from the highway into the existing environment. A stormwater management plan that adequately addresses project goals should also be developed. Key questions, such as “What is the impact of the highway on the existing conditions?” and “What are the potential impacts of the existing conditions on the highway corridor?” should be included to ensure the intended drainage design meets or exceeds the required performance for such a sensitive alluvial plain.

Project: Phase 1C, May Pen to Williamsfield							
Location: Sandy Bay, Clarendon to Williamsfield, Manchester							
Client: ESL							
Date: Jan 2017							
Rational Equation							
Q=0.00278 CIA		Metric units					
Where,							
Q = peak runoff rate (m^3/s)							
C = runoff Coefficient from Table in Sheet 2							
I = average rainfall intensity (mm/hr)							
A = the drainage area (hectares)							
Pre- Construction		**Values obtained from Drainage and Hydrology Report, Volume II (2000), Stanley Flood Risk Study along Highway 2000 (2012) and WRA flow measurements**					
Return Period			**1:50yr**	**1:25yr**	**1:25yr**	**1:25yr**	**1:50yr**
Km			44+200	48+560	*52+380*	*54+750*	59+000
Name			Rio Minho Bridge	St Ann's Gully	*1st order of Rhymesbury Gully*	*Flemmings Gully*	*Milk River Bridge (Required)*
Catchment Area	km^2		444	52	724	446	80
Design Rainfall	mm/hr		292	-	360	360	364
Length of watercourse	meters		-	-	4,286	5,642.0	-
Elevation difference over water course			-	-	81	501	-
Runoff Curve Number	m^3/s		-	-	75.00	75.00	-
Discharge	m^3/s		2577	136	44.60	30.30	102
Post-Development - road surface runoff being added to these discharge points							
		Typical Road Section	43+850	48+150	*49+300*	*49+400*	*68+100 to 69+000*
		100m length	Rio Minho Bridge	St Ann's Gully	*Dry Gullies of the St Annes Gully*	*Flemmings Gully*	*Drainage pathways to Milk River*
C	unitless	0.9					
I (depends on segment)	mm/hr	360.0					
A (est. area of a typical 100m length of highway)	hectares	0.3					
Conversion factor		0.00278					
Calculated Peak Discharge for 100m length of highway, Qr	m^3/s	0.23	2,576.70	135.50	44.6	30.3	102.0
Factor equal to nos. of 100m length of road draining to section		1.0	12.0	24.0	5.0	5.0	15.0
Discharge = factor x Qr		0.23	2.7	5.40	1.13	1.13	3.38
TOTAL	m^3/s	0.23	2579.40	140.90	45.73	31.43	105.38
*est. from Google Earth							
Percentage change			0%	4%	3%	4%	3%

Figure 5.3: Pre- and Post-Construction Runoff Calculations

Post-construction, flood flow characteristics at each highway stream crossing should be carefully analysed to determine with reasonable care their effect upon the highway as well as to evaluate the effects of the highway on flood flow. It is considered important to identify flood hazards prior to any highway involvement to determine how the known flood hazard will be affected with the proposed highway corridor. Flood hazards should include effects to private property both upstream and downstream (i.e. changes to flooding such as overtopping floodwaters diverted in to previously unaffected depressions). The mitigation measures that direct engineering action must be based on an understanding of the dynamics of the alluvial plain before final selection of final mitigation steps are recommended.

The engineering design must include the hydraulic and environmental considerations of each highway river crossing and encroachments. Sections of this report have outlined the environmental considerations along with outlining previously known flooding events. However, the project needs to include a hydraulic evaluation of the effects of floodplain encroachment by a 15km highway.

Post-Construction Backwater Effects

Studies performed by Deassu-Soprin (2000) suggest that backwater effects will be experienced at each crossing. Their summary evaluations for backwater effects are outlined for the Rio Minho and St. Anne's Gully.

<u>RIO MINHO</u>

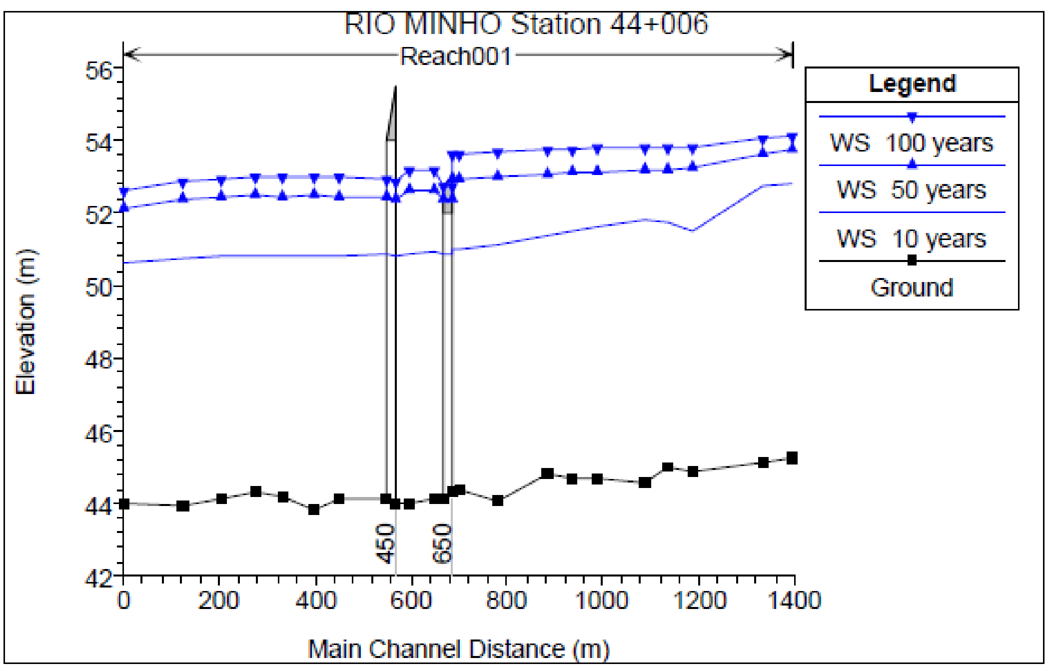


Figure 5.4: Hydraulic assessment by Dessau-Soprin (2000) of backwater effects of the Rio Minho Crossing

ST. ANNE'S GULLY

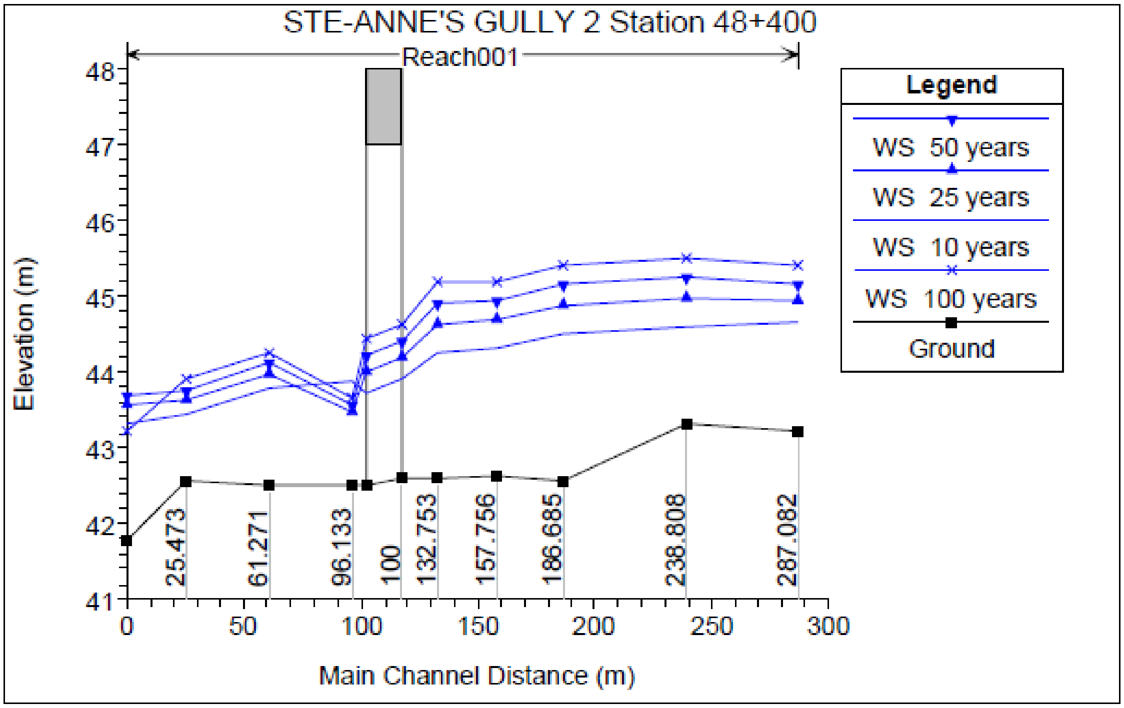


Figure 5.5: Hydraulic assessment by Dessau-Soprin (2000) of backwater effects of the proposed St. Anne Gully crossing

Both the Rio Minho and St Anne's Gully indicate backwater effects up to 750m and 200m upstream, respectively. The impact on upstream considerations is unknown and should be evaluated by a comprehensive floodplain analysis for the length of the highway that encroaches on the alluvial plains.

An assessment of the Milk River crossing was not seen, however, given the concerns regarding flooding at Milk River due to groundwater flows emerging from the Porus Graben and coupled with the likelihood of increased precipitation due to global warming, an assessment of Milk River should be undertaken as well as a re-assessment of all crossings along the proposed corridor.

Backwater effects greater than 0.3m (1ft) within the floodway should be evaluated post-construction.

Groundwater Impacts and Sinkholes

Groundwater surface emergence, where high groundwater levels intersect low ground surface elevations, may be encountered beyond Km58+000 by the alignment. Though no comprehensive scientific evaluation exists, the WRA has estimated that groundwater flow rates at these temporal springs have ranged between 0.1 – 1.5 m3/s during the June–July 2002 torrential rains. Also, these emergent springs occurred mostly between 130 – 180m elevation. Most of these emergent flows occurred within existing natural or man-made depressions/sinkholes (such as Trinity, Berrydale and Harmons), along topographic lows created by faults (Porus, Scott's Pass, Berrydale) and along fault fracture zones (Melrose Bypass). Given that these events have occurred in the recent past, they are likely to occur again in the future, and it is recommended that a hydrogeological evaluation be considered for areas of the alignment that cross areas with a history of emergent groundwater springs. The analysis should provide a means of predicting flow rates and seepage velocities under different environmental conditions. This will allow the best probability of designing subsurface drainage features that will perform as intended.

Mitigating measures that can be considered are underdrains or subsurface drains. Subsurface drains are effective in controlling groundwater problems when designed and constructed properly. Many pavement and slope failures can be prevented with effective drainage of groundwater. Underdrains are used to intercept subsurface seepage before it enters the structural base material supporting the pavement and are also used to maintain a low water table.

Pipe underdrains consist of a perforated or slotted pipe placed near the bottom of a narrow trench backfilled with permeable backfill material. This backfill is typically wrapped in a filter fabric to prevent clogging of the drain due to the migration of finer material. A French drain is an underdrain that consists of a trench backfilled with highly permeable material, but without the perforated or slotted pipe.

Underdrains can be effectively used in the following situations:

- Longitudinal (parallel to roadway) underdrains can be used in regions of high groundwater to intercept subsurface water before it can reach and enter the materials supporting the pavement (e.g., along the Melrose Bypass);
- In sloping terrain, where slope stability is not a problem, a trench may be excavated along the uphill side of the roadbed near the toe of cut slope (particularly where the alignment may intersect depressions);
- In areas where the ground is nearly level, longitudinal pipe underdrains may be necessary along both sides of the roadway bed near the toe of cut slope (between Four Paths and Clarendon Park);
- Longitudinal underdrains are also placed along the toe of fills to intercept high groundwater;
- Transverse underdrains should also be placed at transitions from cut to fill to prevent saturation, settlement and instability in fill sections.

If self-contained sewage systems cannot be utlilized, then the sewage disposal system should have at least 2m of low permeability natural soil between the base of the sewage disposal system and virgin soil or bedrock. No soak-away sewage systems should be sited directly on limestone bedrock.

Sinkholes and depressions should be avoided where possible, but if unavoidable then general guidelines for the treatment of sinkholes should be developed and implemented. Sinkholes should be evaluated to determine if storm water can be diverted away from the sinkhole. If avoidance is not possible, then there should be a buffer zone to filter sediments from the drainage flows prior to discharge to the sinkhole.

The general mitigation and treatment during construction would be to:

- Excavate any soft material and remove debris to a depth specified by the site's geotechnical engineer. If the sinkhole is to be enlarged, it should only be done to allow the installation of filter material to improve flow;
- Place a woven geotextile at the bottom and place 100/300mm rip-rap;
- Ensure that no sinkhole is infilled or permanently covered unless a proper evaluation has been undertaken to indicate that the sinkhole does not contribute to the overall efficiency of the natural drainage system.
- Hydrogeological supervision at sinkholes and depression is recommended.

5.1.1.4 Hydrological Mitigation Measures

Following are measures to reduce the impact of the hydrologic and hydrogeologic environment, however, these could be better informed by a floodplain encroachment evaluation, and these have been considered in the design phase due to the significant flooding risks that the highway corridor will traverse:

- Water supply for the highway corridor is more than adequate.
- Introduction of pollutants into the limestone or alluvial aquifer is a potential risk if appropriate chemical control measures are not implemented.
- Sewerage disposal, particularly during construction, can be a considerable potential significant impact if the appropriate sewerage systems are not implemented to protect the limestone and alluvial aquifers. This impact is completely controllable once the precautions outlined are implemented by the developers to ensure that at least 2m of natural soils exist between any disposal areas and the limestone bedrock or 2m above the highest groundwater levels. In the alluvial soils, a 2m buffer above the highest groundwater level should be maintained.
- The pre- and post-runoff calculations indicate that the post-development runoff will not significantly increase created runoff. Where there are deeper community concerns about drainage, these can be mitigated by the use of holding/detention ponds to reduce runoff volumes and velocity allowing the systems to cope adequately with any created runoff.

- An analysis of the number of cross-culverts per line km of highway should be assessed to ensure that there are sufficient and suitable crossing along the flat and mountainous areas. Internationally, it is recommended that that there should be at least 2.57 cross-culverts per km of road with a minimum average size of 1m. Given the known flooding issues and known concerns regarding sheet flow and concentrated flows upstream of the alignment, at least 3 cross-culverts per km of highway should be considered along with minimum openings of 1.5 to 2m. Based on the foregoing baselines there should be at least 72 and possibly up to 84 drainage crossings including culverts of different sizes and bridges along the proposed 28km highway. This analysis is a rule of thumb and do not deal with the size and location of those structures.

- Groundwater rise has been identified as a long-term, but infrequent risk, particularly west of Km56+000. Its control will need to be assessed on a site-by-site basis to ensure that the appropriate engineering solutions (underdrains, etc.) are implemented where groundwater emergence could be an issue.

- Flooding due to groundwater rise is a pre-existing condition along the corridor and the area has been identified as far back as 1913. The highway's impact on the existing hydrogeological conditions is neutral in the long term once appropriate engineering designs are adhered to. However, perception of its role in exacerbating an already existing structural flooding hazard, particularly in the hills beyond Km56+000, is likely being over-exaggerated.
- In mountainous areas of the alignment the release of runoff should respect natural drainage pathways and ensure discharges are directed to these existing gullies; provide bank protection and stabilisation where required, even outside highway right-of-way to reduce impact on communities outside the right-of-way; any cross-culverts should be re-profiled to ensure grade continuity with the existing pathways; sedimentation and erosion must be controlled during construction and post-construction. During construction, check-dams should incorporated within existing drainage pathways to reduce sediment loading and flow velocities downstream.

Recommendations

Given the foregoing guidelines, it is recommended that:

- All storm drain outlets that discharge to sinkholes/depressions shall have suitably sized, oil/water interceptors to prevent the release of toxic chemicals which could pollute the aquifers. Surface water runoff can contain contaminants such as oil, organic matter and toxic metals, particularly from the toll plazas. Although often at low levels, cumulatively, they can result in poor water quality in receiving water systems. After heavy rain, the first flush is often the most polluting. Given the proposed end-use, incorporating oil/water interceptors within the drainage system should be a primary design criterion. This will allow effective management of the contamination risks associated with storm runoffs from the highway.
- Backwater analyses (such as HEC-RAS) to compute water surface profiles should be analysed for all major crossings, including the Milk River crossing, and for any typical smaller culverts. It would be recommended that such backwater analysis be undertaken for all crossings (bridges, culverts, weirs and structures) between the Rio Minho and Milk River floodplain to ensure that backwater effects due to the alignment is understood both upstream and downstream and incorporated into the drainage design philosophy of the highway. It is recommended that the US Federal Highway Drainage Design Manual – Hydraulics is used.
- Swales/detention ponds should be incorporated into the overall drainage design to provide areas of temporary storage and percolation during construction and more sustained sediment control during operation. Swales are particularly useful for sheetflow and shallow concentrated flow interception and channelling to cross-culverts. Areas for locating retention ponds/swales could be between the edge of the road deck and the end of the right-of-way corridor. A sediment control plan should be incorporated into the overall site construction management plan at all river crossings during construction.

- Drainage solutions must be checked at least twice per year, preferably prior to the start of the two wet seasons, as part of the regular maintenance to remove any accumulated debris and correct any problems identified.
- Along the highway centreline, an open median type lateral ditch with a triangular cross-section should be considered. If runoff on the carriageway flows towards a Jersey type median then a longitudinal culvert should be added under the Jersey median to intercept this runoff and discharge it to a suitable cross culvert. A sufficient number of inlet openings will be required to avoid accumulation of water on the carriageway. On the mountainous sections, water travelling in these median longitudinal culverts will flow at a higher velocity and consequently additional cross-culverts may be required to evacuate the water from the longitudinal central culvert to a lateral ditch. An open type median, rather than a Jersey type median, may be preferable, particularly at locations were overtopping may occur or where protection of the carriageway is paramount from a drainage point of view.
- Irrigation canal should be adjusted as required to allow the transfer of water from one side to the other side of the carriageway i.e. from upstream to downstream.
- The highway design philosophy should include a hydrologic analysis to determine flood flows, then a hydraulic analysis to determine the alternative designs based on the site conditions and to accommodate flood flows. The final step should be the engineering evaluation of the preliminary designs and selection of the final designs taking into consideration all historical considerations, environmental and social considerations and geological/hydrogeological considerations.

Critically, local and national authorities will need to ensure that drainage systems within their jurisdiction are kept clean and free of debris, and upgraded where necessary. NROCC's flood assessment report along the corridor in 2012 outlined several remedial steps along with costs that need to be taken by local parish councils to correct pre-existing flooding issues along the highway corridor.

5.1.1.5 Water Supply Impacts and Mitigation Measures

The main source of water supply for Clarendon is from wells and there are a series of them for domestic water supply as well as for irrigation supply. Emanating from their sources the National Water Commission has a series of distribution pipelines in the area but these with relation to this project are constrained to the existing roadways and are therefore potentially impacted by the proposed highway only where the highway and these roads will intersect. The pipelines are buried below the existing road surface and as such as the highway crosses over these roads it will not affect the pipelines. There may be a requirement to relocate the pipes out of the construction zone of the highway where there is construction traffic from the construction reservation onto existing roads. In these cases, the pipelines may have to be temporarily relocated, but would be reinstated to their previous routing once the construction is complete in these areas. In the Broadleaf to Porus area, the highway route crosses an NWC 10 inch cross country main and this will have to be relocated along the exiting Trinity road near to the railroad crossing and therefore treated as described above and eliminating any pipeline from beneath the highway reservation.

Table 5.1: Location of Intersections of Highway and NWC Pipelines

Item	Location	Pipe Size (Diam. In Inches)
1	Broadleaf/Porus	10 (cross country)
2	Red Berry Road	1
3	Toll Gate Road	8
4	Decoy Road	4
5	Comfort Village Road	4
6	York Pen/York Town Road	3
7	May Pen Bypass to York Pen Road	1

One of the NWC reserve wells is along the highway route near to the start of the extension at the Rio Minho and this resource will be lost because of the highway. This well is not indicated the on NWC's map showing their infrastructure (Figure 5.6). The other wells are either north or south of the alignment and will not be impacted by the construction.

Water will be required for various purposes during the construction including concrete batching and for dust control, water can be hauled from nearby NWC or NIC well sources but adequate storage will be required to assist during potential periods of drought. Temporary storage would best be suited close to one of the available and most reliable sources. Should the local sources become severely stressed then the contractors will have to provide longer haulage of water from wells further east and not rely on the wells closest to the construction.

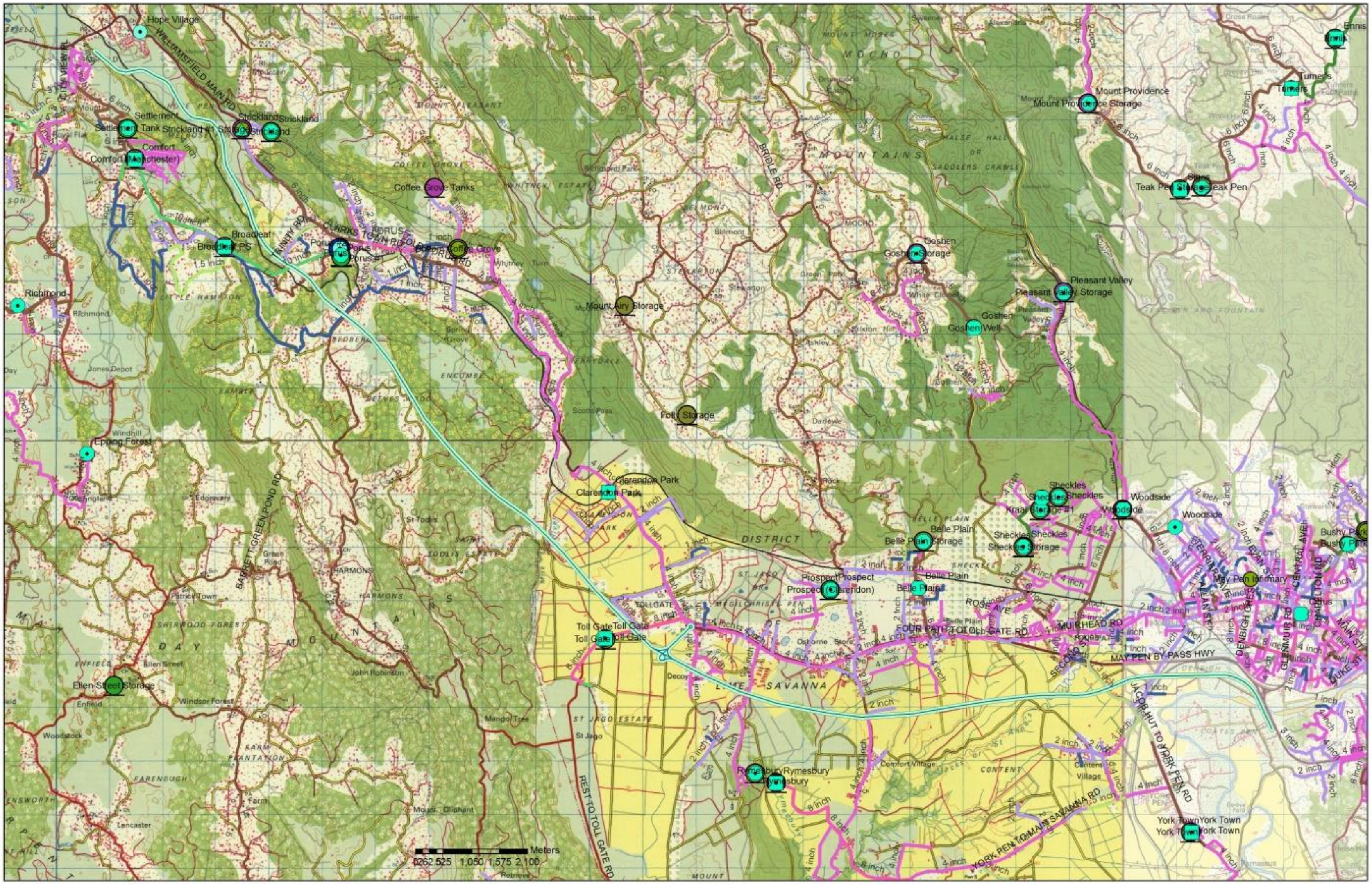


Figure 5.6: Location of NWC infrastructure Relative to the Highway Alignment (Source: National Water Commission, 2017)

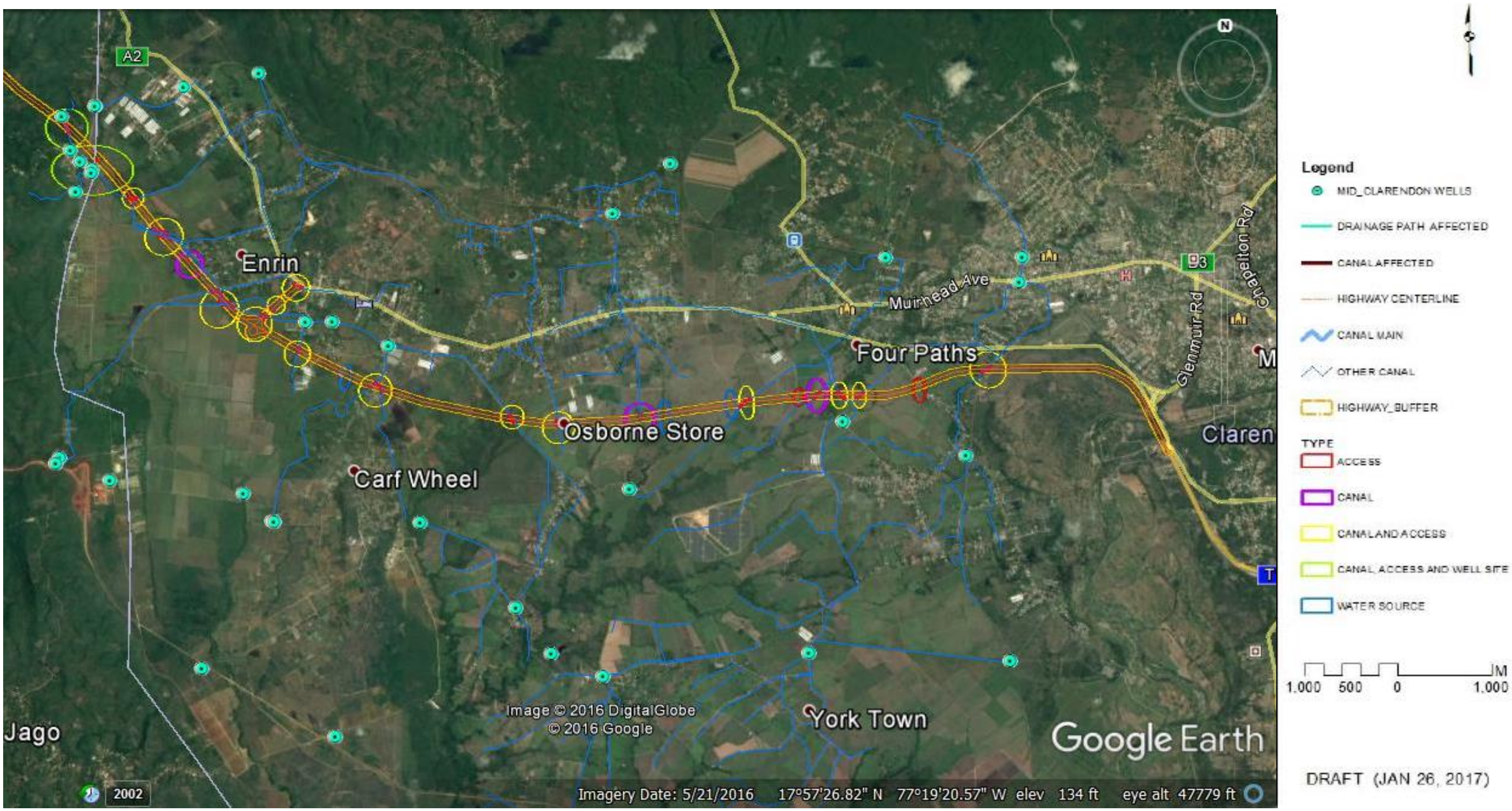


Figure 5.7: Assessment of Highway 2000 on NIC's Mid Clarendon District Network (Source: National Irrigation Commission, 2017)

The NIC also has wells but only one close to St. Toolis (#24 in Figure 5.7) may be of particular concern based on the highway route. The highway does cross irrigation canals as illustrated in Figure 5.7 (#4, #12, #19, and #22) and as such these will pass under the highway. See Table 4.8 in Section 4.1.5.1. The water from the canal will either remain in the canal, which will flow through a tunnel/box culvert or conveyed through a pipeline laid in a tunnel/box culvert. In either case the passage will be large enough to accommodate maintenance crews.

5.1.1.6 Air Quality Impacts and Mitigation Measures

The possible adverse impacts on air quality from activities of the construction phase are outlined in Table 5.2.

Table 5.2: Adverse Impacts on Air Quality from Construction Activities

Main Issues	Sources	Possible Impacts	Possible Impacts		
			Duration	Magnitude	Type
Impacts Due to Construction of the Highway					
Increase in air pollutants and dust	• From land clearing • Improper storage and transportation of fine earth material • Burning of vegetation and/or construction/domestic waste • Fugitive dust from unpaved roads	Adverse health impact contractors, employees, residents and animals etc.	Short-term	Minor	Reversible

5.1.1.7 Noise Impacts and Mitigation Measures

It was noted that noise levels for 5 out of the 7 areas assessed already exceeded the residential noise limits based on traffic and other background noises. It is likely that during construction all the communities will experience a further increase in noise levels during the construction period.

It is recommended that notices be given to residents of each community on when construction activities will start and also when extremely noisy activities will take place. Noisy activities should be restricted to daytime hours and monitored based on the noise abatement standards. Noise should be monitored along the highway during construction to keep track of levels and implement additional mitigation measures accordingly. It is also critical that all vehicles and other machinery being used be serviced regularly and appropriately muffled, where applicable, to ensure that they do not add to the noise levels. All residents would be notified of blasting activities which may not only cause noise, but would result in unpleasant vibrations.

5.1.1.8 Water Quality Impacts and Mitigation Measures

The possible adverse impacts on water quality from activities of construction activities are outlined below.

Sediment runoff

- Clearing of land
- Improper storage of fine earth material near to drains and/or streams
- Damage to aquatic ecology and/or flooding problems
- Pollution from leaching of construction spoils
- Sedimentation and erosion control plan should be developed that addresses construction on the alluvial plains and the mountainous areas separately

Sewage

- Disposal of improperly treated or untreated sewage
- Odours
- Contamination of water with pathogenic organism. Spread of waterborne diseases
- Eutrophication of receiving water bodies
- Damage to aquatic ecology

Disruption of surface water – Changes in hydrologic regime

- Improper storage of construction material or refuse
- Removal of exiting natural drains without appropriate alternatives
- Damage to aquatic ecology and flooding

5.1.2 Biological – Impacts and Mitigation

5.1.2.1 Potential Impacts on Sensitive Ecosystems and Suggestions for Mitigation Measures

Alluvial plains

The most sensitive ecosystems on the alluvial plains are the freshwater river, ponds, streams and canals, which support the movements of the Jamaican Slider and fish and other species and they may also support rare aquatic plants. These ecosystems are threatened by alien invasive species, habitat conversion and pollution. It will be important to maintain the drainage provided by these systems. The design of the road as the number and placement of culverts will be of great importance in maintaining the natural functions and movement of wildlife on the north and south of the road. It is likely that the road will result in some disruption in the drainage which will affect movement of aquatic species. The area of Clarendon Park and Osborne Store is known to be prone to floods and the highway may result in some restriction of flows that might increase the flooding. Changes in drainage could also affect the stability of coastal mangroves, as well as increasing the outflow of sediments to the sea. It is very important that adequate provision should be made for drainage on the plains.

Riparian vegetation is an important habitat and increases the stability of the banks. This should be maintained where possible. Protection of vegetation in stream corridors should be considered as mitigation against erosion and flooding.

Mesic forest on limestone with scattered rural settlement, cultivation and bauxite mining

Concerns about putting roads through upland forests usually centre on changes in connectivity, changes in humidity and impacts on migration of species as well as the possible impact of the road as a conduit for invasive species. However, the road corridor is already highly fragmented by agriculture and mining and dissected by roads. The biggest impact is likely to be the direct removal of trees and excavation of hillsides. This could disrupt drainage and have a major impact on traditional patterns of land use and use of the natural resources of the forests.

5.1.3 Socioeconomic Impacts and Mitigation Measures

5.1.3.1 Employment

During the construction phase employment will be generated for skilled and unskilled labourers as well as for some professionals. Additionally, the supply of goods and services to support workers is also expected to be a positive impact during the construction phase.

5.1.3.2 Health and Safety

Roadworks are likely to impact negatively on nearby residents in terms of dust, noise and vibrations as discussed in Sections 6.1.1.6 and 6.1.1.7 above.

Figure 5.8: Assembly of the First Born Church in Decoy has concerns about noise pollution given it's proximity to the proposed alignment

5.1.3.3 Traffic

Traffic diversions may also become a nuisance during the construction period within communities, such as, Four Paths, Osborne Store, Decoy, Toll Gate, St. Toolis and Porus.

5.1.3.4 Heritage

Despite the lack of visible archaeological/cultural remains, due to the historical uses of the site, there may be a possibility of encountering such remains, though limited. As a result, contractors during excavation should be alerted to report any find during the construction process, in the event that excavation on land and/or the dredger disturbs a deeply buried site. A provision for chance-find should be made and the procedures to be followed in the event of an occurrence should be communicated to the contractors.

5.2 Operational Phase – Impacts and Mitigation Measures

Operational impacts are presented below based on the permanency of the highway operations. Physical and socioeconomic potential impacts and mitigation measures for those that are deemed negative are elaborated in Sections 5.2.1 to 5.2.2 below. The operational biological impacts are also deemed to be cumulative and as such are discussed in Sections 6.1 to 6.3.

5.2.1 Physical – Impacts and Mitigation Measures

5.2.1.1 Hydrological Impacts and Mitigation Measures

In the operational phase, the highway could have an impact on the quality of the receiving surface water bodies particularly from deleterious material washed from the roadway such as oils and fuels that are usually very concentrated in the first flows from highways particularly after accidents, vehicle leakages during break-downs and other accidental spills.

All major bridges are to be designed to pass the 100-year storm event with a minimum freeboard of 1.0m between the lowest point of the bridge (soffit) and the 100-year high water level. Culverts of under 5.0 metres in total open width are to pass a 25-year storm without surcharge (overload) and to provide a minimum of 600mm of freeboard between the edge of road and the high water level during a 100-year storm event.

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 300mm 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 1.0m 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 100-year runoff event that cannot be conveyed by the minor drainage system. The system highway should be checked to ensure that it is not inadvertently cut off drainage on plains and that it can convey the major storm (100-year) without affecting the highway or creating backwater effects along its length. Overflow routes from road deck to the receiving system must be designed to ensure that water does not pond to excessive depths (> 300 mm) on the highway deck 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, particularly upstream.

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 for instance gabion mattresses or riprap. Trash screens will also be installed, where appropriate, to reduce off-site conveyance of highway-derived garbage.

Measures to mitigate against long-term erosion such as grassed swales designed to promote runoff infiltration and reduce exit velocities and maintained annually; constructed wetlands to treat runoff from toll plazas; and implementing a chemical control management plan, will all work to reduce runoff and pollutant loading to streams and rivers.

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 drainage systems and causing blockages – routine maintenance will be required.

- Strategically placed oil/water interceptors should be installed on the primary minor drainage systems that discharge to any water courses/gully or stream, in order to minimize hydrocarbon discharge to watercourse and these should be placed on drainage systems exiting toll plazas or where discharges are directed to any sinkhole/depression.
- Catchpit manholes may be installed to provide areas of sediment control and flow controls were the available right of way 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 watercourses and where practicable to do so. The longitudinal ditches which flank the highway will also be looked at as polishing areas prior to discharge to perennial water courses, such as the Rio Minho and Milk River.
- Water discharge to sinkhole or depression must be agreed with the WRA and pollution control measures installed.
- Planting on the verges will be a requirement to reduce soil erosion and suspended matter.
- Closed drains shall be used in areas where overburden depths on the limestone aquifer is shallow or non-existent; areas with less than 1m virgin soil cover or exposed bedrock should be considered as high vulnerability areas, particularly if fractured. If after final graded levels, there are still areas where the limestone is covered by less than 1.5m of natural, slow draining soils or there is exposed limestone at the surface, then closed drains must be incorporated.

5.2.1.2 Water Supply Impacts and Mitigation Measures

Operations of the NWC are not affected by the highway as the pipelines are in the existing road reservations. The reserve well is lost to future water supply demand and the system capacity is reduced and as such a replacement source will be necessary.

Operations of the NIC will be affected where the highway crosses existing intervals in the cane growing areas. The highway will allow for existing municipal roads but not the roads within the cane fields. Whereas the NIC presently uses these intervals to access their wells, canals and pipelines the highway will cut off these routes and they will have to use the main roads to access the locations and this will increase travel distances and time.

5.2.1.3 Air Quality Impacts and Mitigation Measures

During operation, it is likely that there will be an increase in air pollutants and dust. Fugitive dust will result from the area’s lack of vegetation and the increase in traffic, which can cause adverse health impacts for contractors, employees, residents and animals, etc.

There is a chicken coop located downwind of the proposed highway alignment, in the vicinity of Tool Gate. Any negative impacts are expected to be minimal and sporadic and will be dependent on changes to the existing wind direction. The impact will be in the form of an odour nuisance

5.2.1.4 Noise Impacts and Mitigation Measures

It was noted that noise levels for 5 out of the 7 areas assessed already exceeded the residential noise limits based on traffic and other background noises. It is likely that during operation, those communities that are densely populated and within close proximity to the alignment, will experience a further increase in noise levels. This can adversely impact persons living in residences nearby. The following nine (9) locations were examined in relation to the need for noise prevention barriers.

Table 5.3: Determination of Noise Barriers

	Coordinates	Communities	Recommendation/ Comment
1	17°57'45.36"N, 77°16'36.20"W	Between May Pen and Four Paths	Not needed
2	17°57'37.82"N, 77°17'6.46"W	Between May Pen and Four Paths	Not needed
3	17°57'34.23"N, 77°20'55.48"W	Decoy whether church taken or avoided.	Noise Barrier on both sides of alignment. Whether Church taken or not. Community expansion up to highway likely.
4	17°57'44.84"N, 77°21'21.85"W	Before interchange at Tollgate	Not needed
5	17°58'10.83"N, 77°22'2.72"W	After interchange at Tollgate	Not needed
6	18° 1'24.66"N, 77°25'12.20"W	Porus	Not needed
7	18° 1'48.02"N, 77°25'36.77"W	Porus	Not needed
8	18° 2'0.78"N, 77°25'54.30"W	Porus – near Trinity Road	Noise Barrier for south bank travelling north.
9	18° 4'4.62"N, 77°27'51.30"W	Royal Flats	Not needed

The criteria applied as best as was determinable, were the presence/absence of sensitive activities such as: Assemblies for worship, day care centers (or schools) recording studio activities, homes used for caring of the elderly, community centers or parks, sports fields likely to be used for sporting or larger social/entertainment activities. Ultimately, considerations regarding residential housing ended up being the main determinant of the recommendations made.

The recommendations are made with this caveat. Where the final alignment is determined to likely infringe best highway construction noise abatement standards or where other best practices exist, these should be given precedence in any final decision on the alignment.

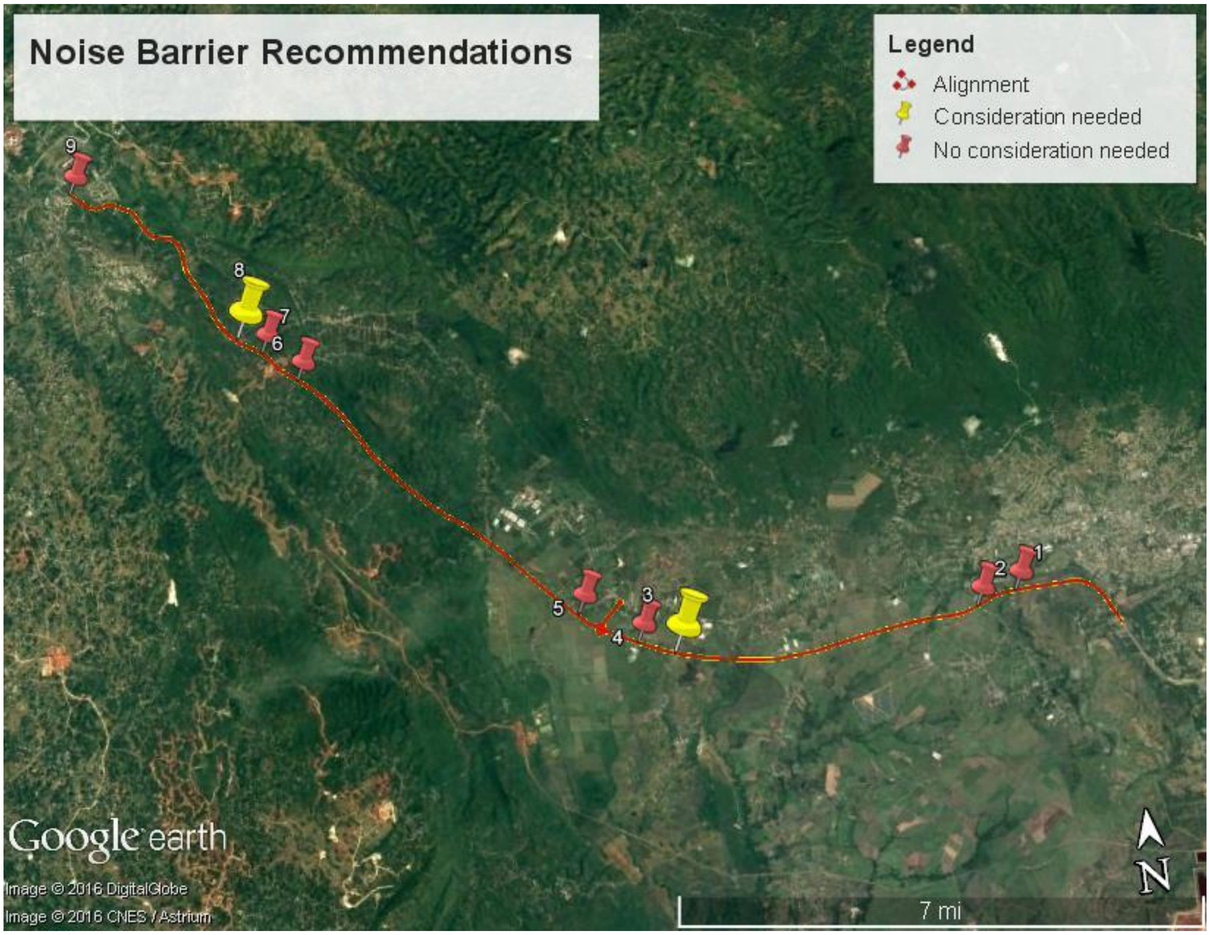


Figure 5.9: Noise Barrier Recommendation

Additionally, notices should be given to all residents nearby for planned maintenance activities that will increase noise levels.

5.2.1.5 Water Quality Impacts and Mitigation Measures

During operation, it is likely that drainage and surface run-off into the environment will increase. Sediments from areas without foliage can result in flooding, infrastructural damage and siltation of receiving waters. It is essential that drains be designed appropriately to accommodate flood water expected for the area. Additionally, sediment traps could be considered as already discussed in Section 6.1.1.2.

5.2.2 Socioeconomic Setting

5.2.2.1 Economic & Social

In the context of an EIA of this scope, the prediction of economic impacts must remain conjectural. An economic justification for the H2K programme had been made using a traditional cost benefit analysis approach, which compared the flows of investment and operating costs over time with benefit flows (*Jamaica Development Bank – Dessau. Economic Cost Benefit Highway 2000 Project; Preliminary Design Phase. 2000*). This study shows both positive and negative results which have been presented in Appendix

V. As it relates specifically to the May Pen to Williamsfield corridor Sections 5.2.2.1.1 and 5.2.2.1.2 elaborate.

5.2.2.1.1 Negative Impacts

The anticipated negative impacts will also be felt mainly in retail, eat/drink and gasoline. The positive impacts will be consistent with the expectations of the Development Bank of Jamaica & the Dessau SEA study.

Table 5.4: Predictions of Potential Impacts on Near Communities

Communities	Specific Risks	Mitigation	Positive Impacts
Osborne Store	Retail, Eat & Drink and Gasoline	Housing and commercial developments into Clarendon as commuting time East/West decreases	Noise and air pollution reduction due to traffic diversion Safety Travel time savings
Clarendon Park	Retail, Eat & Drink and Gasoline	Housing and commercial development into Clarendon as commuting time East/West decreases. An interchange and likely vending park would be significant.	Noise and air pollution reduction due to traffic diversion Safety Induced development Travel time savings
Toll Gate	Retail, Eat & Drink and Gasoline	Housing and commercial development likely to be too long-term to be seen as a mitigation measure	Noise and air pollution reduction due to traffic diversion Safety Travel time savings
Scott's Pass	Retail, Eat & Drink	Housing and commercial development likely to be too long-term to be seen as a mitigation measure	Noise and air pollution reduction due to traffic diversion Safety Travel time savings
Porus	Retail, Eat & Drink Services and Gasoline	Housing and commercial development likely to be too long-term to be seen as a mitigation measure	Noise and air pollution reduction due to traffic diversion Safety Travel time savings
Melrose Hill Bypass	Eat and Drink	The relocation of vendors would be a positive mitigation measure.	Safety Travel time savings

However, Old Harbour on the Bushy Park to Sandy Bay leg of H2k is an example of a community that once seemed seriously threatened by the new alignment. Because of rapidly induced housing developments, as a direct consequence of travel time savings, it now appears to be experiencing recovery through its retail and services sectors.

The alignment is generally not disturbing of the main land uses in the project area. Where it impacts, it does so on a very limited scale. It does not significantly affect neighbouring land use even in those communities where structures are actually impacted.

With one exception, where it impacts a playing field in the Toll Gate area, no obvious communally used recreational or green areas are directly impacted, though these are not necessarily well defined by recreational structures and may simply be fields of play.

Similarly, the alignment, which runs generally south of the existing A1 alignment, does not partition individual communities in any significant way, as overpasses preserve existing communication access. Neither, for the same reason, does it act as a barrier between neighbouring communities.

Yam Park

The new alignment is along the Melrose Bypass and will cause the displacement of about 15 Yam Park vendors and workers (Figure 5.10). The rapid appraisal interviews, supported by interviews conducted directly by the Consultants, found that about 60% of this population favoured that construction of the highway and 40% thought it was unnecessary. All were concerned about the potential loss of earnings that any closure of the Yam Park threatened.

Figure 5.10: Melrose Hill Yam Vendors (Photo source Jamaica Gleaner)

The vendors were in support of being relocated but were not in support of a relocation into Clarendon since almost all live in the Williamsfield area. They suggested relocation to an unspecified site at the end of the proposed alignment in Williamsfield, pointing out that any new site for the park had to take into account the potential smoke nuisance to residential or other food vending locations (Figure 5.11). Parish Council officials supported the views of the yam vendors, and argued further that the Melrose yam was a Manchester tourist product and also, through user fees, a source of revenue for the Parish Council. The developers of the Highway are currently exploring alternative relocation sites. Any such site should be subjected to an environmental assessment to ensure its suitability and acceptance by NEPA.

Figure 5.11: Photo showing the Location of the Entrance of the Alignment at Williamsfield, which is currently the area used as an Informal Agricultural Transhipment Point.

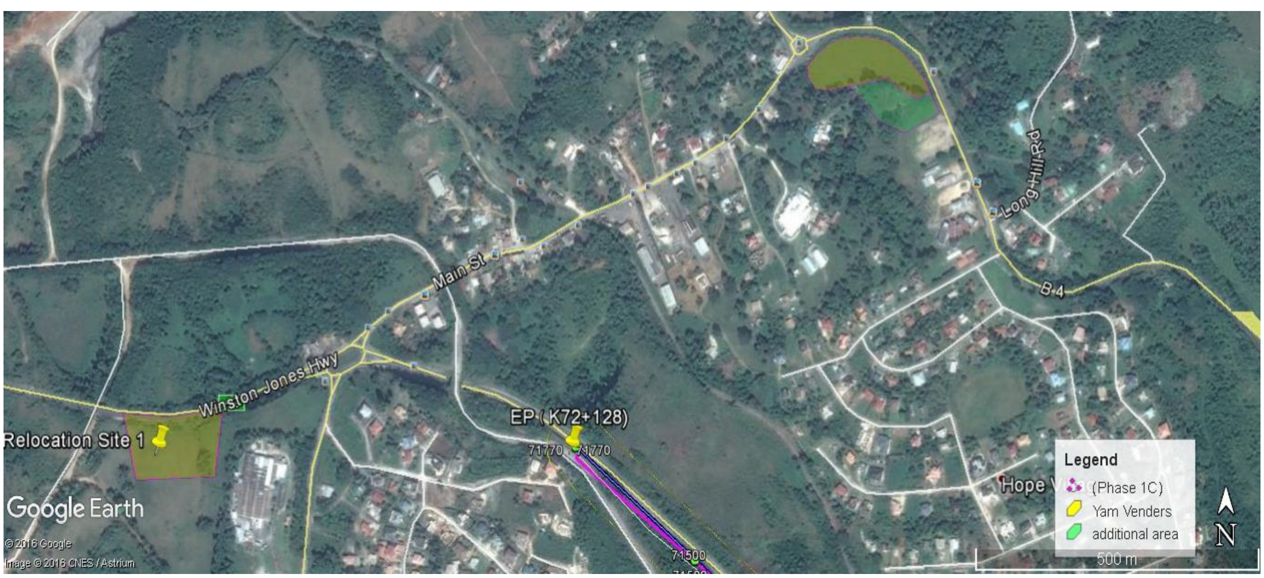


Figure 5.12: Proposed Location for Relocating Yam Vendors (Source: NROCC, 2017)

Porus and Scott's Pass Area Fruit Vendors

Between the turn off to St. Toolis and the community of Porus is an important traditional citrus and other fruit vending area. Vending typically takes the form of informal stalls located directly on the main road. The majority of these vendors live beside or near to their stalls.

Table 5.5 presents the number of vending stalls located between turn off to St. Toolis and Porus/Melrose

Table 5.5: Number of Active and Inactive Vendors

Area	Abandoned or Inactive	Active
St Toolis to Scotts Pass	2	0
Scott's Pass to Berridale	6	5
Berridale to Porus	0	10
Porus to Melrose	0	1
Total	8	16 Total = 24

The population of vendors is thought to be about 50. Most stalls are operated using family labour (Figure 5.13). Discussions with key informants suggest that the vendor population has been declining over the last several years.

During this limited one day survey, approximately 33% of the stalls seen were considered to be abandoned. The reason given for this being the overall decline in the citrus industry. Of the eight vendors interviewed, 63% identified citrus (or oranges) as their main selling item, whilst the remaining vendors identified all fruits as being equal sellers. As a consequence of the economic downturn in citrus, vendors have been relocating their sales to other areas like May Pen and Mandeville. Most vendors surveyed thought their businesses had remained stable over the last two years, albeit with slight increases and decreases within that period. All vendors surveyed report 7-day working weeks, with many working from 7am until after 8pm. The majority of persons employed to the stand (on average 2-3 persons are employed per stall) are family members.

Other key informants suggest that the suggested relocation may not be viewed positively. This is because the proximity of stalls to vendors' homes provides safety for their produce (from weather, theft), reduced transportation costs (for themselves and produce), and a convenient source of family labour.

A high majority of vendors felt the highway would have a negative impact on business as a result of less traffic as their business was highly dependent on motorists passing through the area.

Half (50%) of the vendors interviewed were not in agreement with the highway because of the negative impact to their business, while the remaining half saw the need for the highway and were in general agreement with its construction.

Figure 5.13: Photo showing the typical vending stall is located on the roadside, and passing motorists constitute their main market.

When asked about their interest in an alternate vending site located at a highway rest stop, all vendors surveyed were in agreement even with such conditions as rental payments, the rest stop being non-restrictive to only fruit vending, and with restricted access to highway users only. The majority (63%) of vendors thought that if given the option of a stall at the rest stop, they would continue to operate their current stall (Figure 5.14). The remaining vendors thought they would best close down their existing location. A number of vendors emphasized that should a rest stop facility be established, existing fruit vendors in the area should be given priority.

Figure 5.14: Photo showing one of the typical vendor stalls located in Scott's Pass and Porus, selling citrus and other fruit

Gas Stations

As indicated in Table 5.4, gas stations in Osborne Store, Clarendon Park, Tollgate, and Porus will be negatively impacted by the diversion of traffic. The most likely mitigation offset will be through any induced housing and commercial development brought to the area by the new alignment. The expectation being that these developments would restore business lost from traffic diversion. These observations have been confirmed by key informants, including one of the main gas station operators in the area, who also supported the concept of a Rest and Service Stop near the Tollgate community.

5.2.2.1.2 Positive Impacts

Several positive impacts are expected from the development of the May Pen to Williamsfield leg of the highway. These positive impacts are stated below:

- Generation of Employment/Supply of Goods and Services in the Construction Phase

Employment opportunities will continue for the duration of the project. Opportunities will be created for the supply of various types of construction materials over its duration.

- Improved Transportation Network

The construction of the section from May Pen to Williamsfield will significantly reduce the current travel time between these two destinations, particularly over the current Toll Gate, Porus to Melrose alignment. The journey will not go through the congested townships of Scott's Pass and Porus, in particular. The journey time from Kingston to Williamsfield will be approximately 50 minutes.

- Land Use Planning

The Highway 2000 Corridor Development Plan recognizes that the implementation of Highway 2000 will result in development adjacent to, and in close proximity, benefiting from the highway alignment. It is important that this Corridor Plan be expanded to include those sections of Clarendon and Manchester not presently covered.

Such a development plan is critical to ensuring that the development potential of the highway is optimized within a sustainable framework.

While current land use has been generally described in each of the buffer zones of the alignment, a more detailed land use mapping was undertaken in the Highway 2000 Project Preliminary Design Phase Strategic Environmental Assessment by Dessau Soprin International Inc. (June, 2000).

- Aesthetics/Scenic Values of the Highway Alignment

The highway alignment is a new alignment. The alignment will open up new vistas along this section of the May Pen to Williamsfield alignment, similar to what H2K has done in its other developments.

- Safety

A report on the Summary of Police Activity on the Toll Road dated July 9, 2007 and included in the earlier EIA on this alignment, indicates that even with increased speeds of up to 110kph, the highway can be regarded as safe when compared with the accident and incident counts on normal road surfaces islandwide. Monthly accident reports are submitted to the Toll Authority by Police Traffic Headquarters.

- Distribution of Incoming Goods and Services

The highway is expected to contribute to the distribution of incoming goods and services as improved travel time induces commerce and individual enterprise. Reference to the transhipment of agricultural products at the Melrose Bypass is just one example of this likely trend.

- Recreation

This highway represents an important road and travel time improvement, which will facilitate movement between Kingston and other eastern Jamaica population centres to well-known visitor attractions in Southern & Western Manchester and St Elizabeth. The extension of the highway beyond Williamsfield will enhance this benefit.

5.2.2.2 The Communities Impact on the Project

With respect to the community's impact on the project, this is reasoned as follows.

In high density and site specific environmental impact assessments, typified by a housing or hotel development, the impact of the project on the social infrastructure carrying capacity is different from that occasioned by a tolled highway. The important difference being that the highway's 'population' transits, nonstop, through the communities they encounter and typically do not make claims on any social services. Further, since traffic volumes between destination points (for example, May Pen to Williamsfield) are more a function of vehicle population (which, in turn, is dependent on economic and importation policies), the impact that the communities can have on the highway is limited. Traffic flows on the highway that originate from near communities will determine the vehicle population impact on the highway. Presently, there is only the assumption available to the Consultants, that the highway will, of itself, increase these flows.

5.3 Matrix on Impacts and Mitigation Measures

Table 5.6 Matrix on Impact and Mitigation Measures

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
Construction Phase						
Purchase of sand and quarry aggregate such as from rivers	• Improve the economic viability to the project when material can be sourced cheaply because of proximity to the project activities. This eliminate importing material. • Increase in employment of workers in the river aggregate industry.	Positive	Short term	Major	Reversible	-
	• Strong demand for river aggregate by highway construction could create material shortage for other stakeholders. • Illegal quarrying could be increased due to shortage. • Disruption in traffic due to haulage of raw materials.	Negative	Short term	Major	Reversible	• Manufactured sand and gravel could be exploited by other users in the construction industry as an alternative to river sand/gravel. • MGD should monitor for illegal sand mining. • Limestone aggregate for road bed fill should be sourced from a quarry south of highway to prevent haulage

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
						across A2 main road minimizing traffic disruptions.
Limestone aggregate from excavation as fill	• Large purchase of fill obtained from excavation in the hills of St. Toolis, Reeves Wood and Melrose Hill, reducing construction waste on project.	Positive	Short term	Major	Irreversible	-
	• Material for May Pen to Clarendon segment can be source within short distance from construction activities.	Positive	Short term	Major	Reversible	-
	• If limestone is sources at the northern side of the main road between May Pen and Clarendon Park, then traffic congestion will likely increase	Negative	Short term	Major	Reversible	Mitigation measures elaborated under transportation below.
	• Dust from haulage of trucks travelling from source to construction site	Negative	Short term	Major	Reversible	Mitigation measures elaborated under transportation below. Wetting of roads should be done regularly e.g. preferably 30 minutes and in accordance with best practice.
	• Some community members	Negative	Short	Major	Reversible	• Appropriate signage to

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
	can be hurt by haulage trucks.		term			prevent persons in restricted area and to facilitate detours as necessary. • Ensure appropriately trained drivers.
Alignment hindering bauxite extraction	• A section of the alignment will pass through large bauxite deposits in the mining lease area operated by Jamalco. Namely: Redberry, Reeves Wood	Negative	Long term	Significant	Irreversible	• Discussions with JBI to have a smaller impact so that only a few smaller deposits can become sterilised during negotiation. • Highway should be shifted to the north east to avoid larger reserves in Redberry and reeves Wood based on site visits by both JBI and Highway developers. • Where sterilisation is unavoidable, Jamalco reserves the right to mine out and stockpile any deposits on the north east side of the alignment. • Access to mining on the north east of alignment

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
						should be created and not blocked.
Construction activities blocking sinkholes	• Potential blocking of sinkholes leads to flooding and prevention of storm water to recharge the aquifer.					• Detailed design during the design phase to protect against blockages. • Excavation of soft material to a depth specified by geotechnical engineer. Enlarge sinkhole as necessary to allow for installation of the filter material. • Place non-woven geotextile at the bottom of excavated material and placement of boulders (100/300mm rip-rap)
Cut and Fill	• Cut and fill activities will result in a surplus of excavated material that will need to be disposed of appropriately.	Negative	Short term	Major	Irreversible	• Identify an appropriate and approved site for disposal and management of excess material. • Identify other projects that may require fill material. • Spoil tips for construction waste should be kept as close as possible to the

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
						project site and secured to prevent erosion. • Use surplus for landscaping
	• Landslides are potential impacts in some areas, specifically: tributary of Milk River in St. Toolis; geological faults in Reeves Wood and Melrose Hill Bypass that are susceptible to rockfalls and slides; in St. Toolis where deep cuts are to be excavated in karst limestone	Negative	Short to long term	Significant	Reversible	• Slope stabilisation mechanism to be implemented especially in these specific areas e.g. earth retaining walls. • The landslide area in St. Toolis (along tributary of Milk River) should be avoided. • Use of benched slope in susceptible areas. • Reduce slope angle by cutting back.
Blasting	• Damage to residential dwellings due to blasting vibrations and rock fly in close proximity to blast sites. A residential dwelling located on the foot of the hill in Reeves Wood; residences in the southern section of the town of Porus. • Damage to persons nearby	Negative	Short term	Significant	Irreversible	• Conduct a pre-blasting survey. • Peak particle velocity vibration should not exceed 25 mm/sec. • Detonation for each row of blast holes delayed by 8 milliseconds. • Stemming of the blast drill holes should be sufficiently

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
						deep to dissipate blast energy within ground rather than above ground surface. • Appropriate safety and protective gears for workers
	• The blast energy results in mobilisation of loose limestone on slopes and earthquakes causing potential damage to structures e.g. bridges, secondary roads etc. • Slope failure of unprotected embankments and high road cuts, especially in fault zones.	Negative	Short term	Significant	Irreversible	• Experienced blast contractor with insurance hired. • Blast warning signs to be erected. • Proper management of blast sites. • Seismographs used where necessary to monitor explosions. • Seismic designs to be included as part of the design principles for the highway e.g. IBC code/international seismic code • Slide protection measures to minimize impact of shaking

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
						• Develop earthquake hazard plan.
Sediment runoff and flooding during construction	• Clearing of land • Improper storage of fine earth material near to drains and or stream • Damage to aquatic ecology and/or flooding problems • Pollution from leaching of construction spoils	Negative	Short term	Major	Reversible	• Incorporate into design appropriate non-structural practices to minimize erosion. • Develop an Environmental Protection Plan for which a major component is an erosion and sedimentation control plan. • Erosion and sediment control measures and best practices should be put in place starting from the design phase as elaborated in Section 6.1.1.2 above (e.g. sediment traps, filter fabric fence, vegetated filter strips, grassed swales.
Disruption of surface water and water quality (WQ) b. Changes in hydrologic regime	• Improper storage of construction material or refuse • Removal of exiting natural drains without appropriate alternatives • Damage to aquatic	Negative	Medium to long term	Major	Irreversible	• Proper storage of construction material e.g. cover stockpiles with tarp, drainage paths diverted away from stockpiles. • Proper storage of hazardous materials. These should be

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
	ecology and flooding					lock away when out of use as instructed by material safety data sheet (MSDS). Develop and implement a chemical control management plan. • Erosion control measures as outlined in Section 6.1.1.3 above will minimize sedimentation discharges into the many streams, gullies and rivers. • Monitoring of effluent and discharge points during construction to help keep matters in check.
Water supply disruptions due to existing distribution pipelines in areas along the alignment.	• Water supply from wells in Clarendon for domestic supply and irrigation. Potential damage to pipelines constrained to existing roadways. • Cut off of water supply to communities.	Negative	Short term	Major	Reversible	Relocate pipes out of the construction zone of the highway and relocation of existing roadways will mean that a "sleeve" should be installed and the pipeline inserted through the "sleeve" to allow for access to the pipeline without entering the wayleave of the highway. This will reduce risk of damage and cut-off from supply.

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
Range of activities outlined (blasting, cut and fill etc.) above resulting in poor air quality (AQ)	• Poor air quality impacting residents of nearby communities especially: Four Paths, Osborne Store, Toll Gate, St. Toolis Reeves Wood, Redberry and Porus	Negative	Short term	Major	Reversible	• Dampening of exposed surfaces during dry periods should be implemented as part of the site activities during construction. • Covering of stockpiled fine material. • A phased approach should be undertaken during construction to limit the time locals are displaced. • Limit the hours of noisy activities between 7am and 6pm • PM10 be monitored in µg/m3 using the WHO's ambient air quality guidelines during the construction period. • Develop implementation plan to guide construction activities.
Noise and vibration nuisance from construction activities	• Nuisance and potential hearing damage to nearby residents and workers. Residents of greatest	Negative	Short term	Major	Irreversible	• It may be useful to monitor noise during activity to ensure that decibel is restricted to 70dBA or below

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
	concern are: • York Town Road Four Paths • Denbigh Drive • Decoy at Toll Gate • Duke Street • Redberry • Other health risks triggers from sustained high noise levels.					of sustained noise which is detrimental to human hearing. • Advise neighbouring properties at least 24 hours in advance of planned noisy activities. • A phased approach should be undertaken during construction to limit the time locals are displaced. • Limit the hours of noisy activities between 7am and 6pm • Develop implementation plan to guide construction activities. • Monitoring of noise during construction to help ensure levels in kept check. • Consider temporary noise barriers where communities are more densely populated.
Biological impacts due to land clearing	• Most sensitive ecosystems on the alluvial plains are freshwater river, ponds,	Negative	Short term	Major	Irreversible	Sediment control mechanisms as already discussed above.

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
	streams, canals, which support the Jamaican Slider and fish, along with rare aquatic plants are sensitive to restrictions in water flow and sedimentation. Death in aquatic life can result. • Changes in drainage and sedimentation can also impact the stability of coastal mangroves.					
	• Removal and trees and excavation of hillsides will lead to direct loss of species and disruption in drainage. • Disruptions may lead to change in land use and use of natural resources of the forest.	Negative	Long term	Major	Irreversible	Sediment control mechanisms as already discussed above.
	• The alignment through the upland forest will likely result in changes in connectivity, humidity, migration of species and conduit for invasive species. The area is, however, already fragmented.	Negative	Long term	Minor	Irreversible	-

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
Worker employment	• Generation of employment during construction activities for local community residents	Positive	Short term	Major	Reversible	-
Worker safety	• Accidents and adverse effects on workers may occur on construction sites	Negative	Short term	Major	Reversible	• Worker safety should be protected and safe practices implemented. • Wearing of the appropriate protective gear on site should be stipulated and mandatory. • Sanitary practices in regard to providing potable water and the disposal of human waste should be enforced to safeguard worker health. • Construction crews should be provided with the appropriate safety gears such as hard hats, gloves, safety shoes, reflector vests where appropriate, etc. • Appropriate signage on site to prevent unwanted persons being put at risk.
Traffic congestions	• Road detours and congestion and nuisance to several	Negative	Short	Significant	Reversible	• Trucking material on site during off-peak periods.

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
due to detours and transportation by heavy duty trucks of material – sand and gravel etc.	communities – Four Paths, Osborne Store, Toll Gate, St. Toolis Reeves Wood, Redberry and Porus. • Changes in traffic type and volume are expected to negatively affect traffic flow when heavy vehicles are entering and leaving the construction site to deliver materials and equipment. • Potential dust nuisance arising from transporting light material (AQ mitigation measures already outline above) • Damage to roads and road furnishings, curbs, bridges culverts and poles. • Potential for Personnel accidents and other human vulnerabilities arising from heavy duty vehicles on roads		term			• Appropriate signage during construction. • Ensure that trucks are not overloaded to prevent road damage • Ensure that trucks carrying fine material are properly covered to ensure that material does not litter the road or cause a dust nuisance or damage to pedestrians or housing and business along the truck route. • Ensure that road rules are followed, drivers are qualified, and that trucks are not over the load limit to reduce risk of accidents.
Placement and use of equipment	• Potential dust nuisance to residents nearby construction works (AQ mitigation already outlined	Negative	Short term	Moderate	Reversible	• Inspect (daily) all vehicles and equipment for potential leakage of fuel, oil, hydraulic fluid or coolant. Any

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
	above) • Equipment usage onsite will likely result in high noise levels for an extended period Potential noise nuisance to residents nearby construction works (Noise mitigation already described above) • Contamination of nearby rivers and drains					machinery found to be leaking will be repaired or replaced. • Vehicles and equipment used should be serviced to reduce noise levels. • Standard operating practices for construction should be adhered to: E.g. restricting the time of day that such activities (during work hours)[6]. • Hazardous materials such as fuels and oils should not be stored near storm water drains. • Provide appropriate signage and security for all storage of dangerous goods. All incompatible materials will

[6] World Bank has a 55 dBa daytime limit and a 45 dBa night-time noise limit for residential areas and a 70 dBA limit for commercial and industrial areas for both day and night time.

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
						be segregated. • Provide Material Safety Datasheets (MSDS) for dangerous goods used or stored on-site. Personnel will to be made aware of the environmental and safety requirements for these hazardous materials.
Solid waste disposal	• Construction waste material, and other domestic waste that would be generated on site are to be appropriately disposed. • Poor solid waste disposal pose a health risk. • Poor solid waste management can result in blocked drains and flooding during rainy periods.	Negative	Short term	Major	Reversible	• Refuse bins should be placed on site to meet the needs of the workforce • Arrange for the collection of solid waste by certified contractors and disposal at an approved site • Any hazardous waste should be separated and stored in areas clearly designated and labelled • Open burning of solid wastes should not be conducted as these generate polluting emissions which cannot be controlled effectively. • Garbage storage area should

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
						always be kept clean. • If a bin is damaged, the contents will be transferred to another container in good condition. • The waste container should be of waterproof material to prevent the escape of fluids. • The stored waste should be covered to prevent rain water from flooding the waste and overflow.
Sewage treatment	• Improper sanitary facilities pose a health risk. • Disposal of improperly treated or untreated sewage • odours • Contamination of water with pathogenic organism. Spread of water borne disease • Eutrophication of receiving water bodies • Damage to aquatic ecology	Negative	Short term	Moderate	Reversible	• Construction camps and work areas must be adequately equipped with portable chemical toilets. • Portable chemical toilets must be provided, maintained and removed by a certified contractor to mitigate inappropriate disposal.

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
Potential loss of historical artefacts particularly underground during excavation and blasting	Despite the lack of visible archaeological/cultural remains, due to the historical uses of the site, there may be a possibility of encountering such remains, though limited.	Negative	Short term	Major	Reversible	• Contractors during excavation should be alerted to report any find during the construction process, in the event that excavation disturbs a deeply buried site. • A provision for chance-find should be made and the procedures to be followed in the event of an occurrence should be communicated to the contractors
Operation Phase						
Drainage and surface run-off resulting in flooding and poor water quality	• Sediments from areas without foliage • Quality of receiving waters negatively impacted by washed down oils, fuels and accidental spills from roadway. • Flooding, infrastructural damage, siltation of	Negative	Long term	Major	Reversible	• Drainage constructed at appropriate size. • Since flooding is likely, a design life of 50 years is proposed for the highway, 10 years for minor crossings and 100 years for the Rio Minho and Milk River.

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
	receiving waters • Blockage of sinkholes and					• Determine and implement sediment control measures for each sub-catchment to reduce flow velocity. • Assess scour potential and if required, rip-rap lining or another form of suitable protection should be employed. • Trash screens to hinder highway garbage. • Grassed swales to promote run off infiltration and reduce exit velocities. • Monitoring of effluent and receiving water bodies. • Other pollution control measures as elaborated in Section 6.2.1.1.
Water supply disconnections	• In cases where the NWC pipeline falls within the highway reservation fence.	Negative	Short term	Major	Reversible	• Relocation of pipelines within highway alignment.

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
	Should there be breaks in the line in need of repair, permission would be necessary for them to enter the restricted area. This delay can lead to unnecessary loss of water and potential localized flooding if remains unchecked for an extended period of time.					• Place the pipeline in a sleeve, which will allow the pipe to be extracted and repaired without entering the wayleave.
Increase in air pollutants and dust along the Highway alignment	Adverse health impact contractors, employees, residence and animals etc.	Negative	Short to Long term	Moderate	Reversible	Air quality monitoring at intervals over time
Increase in noise from traffic in densely populated areas	Adverse health impact to nearby persons living in residences. Communities of greatest concern are: York Town Road Four Paths Denbigh Drive Decoy at Toll Gate Duke Street Redberry	Negative	Short to Long term	Major	Reversible	• Erection of noise wall in densely populated areas only • Noise monitoring at intervals over time
Odour nuisance	Chicken coop downwind of highway alignment in Toll Gate may result in a minor odour	Negative	Long term	Minor	Reversible	-

<table>
<tr><th rowspan="2">Activities/ Main Issue</th><th rowspan="2">Possible Impacts</th><th colspan="4">Possible Impacts</th><th rowspan="2">Mitigation Measures</th></tr>
<tr><th>Direction</th><th>Duration</th><th>Magnitude</th><th>Type</th></tr>
<tr><td></td><td>nuisance only if and when wind direction changes. This is likely to be sporadic and vehicular traffic will be moving swiftly pass the area.</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Employment generation</td><td>• Generation of employment during operation activities for local community residents.</td><td>Positive</td><td>Short term</td><td>Major</td><td>Reversible</td><td>-</td></tr>
<tr><td>Highway extension and traffic</td><td>• Reduction in traffic on A2 main road.
• Reduction in time travel due to avoidance of congested communities.</td><td>Positive</td><td>Long term</td><td>Major</td><td>Reversible</td><td>-</td></tr>
<tr><td>Highway extension and social benefits</td><td>Housing and commercial developments increases in Clarendon as commuting time East West decreases, saving travel time. Communities listed below may have these impacts:
• Osborne Store
• Clarendon Park
• Toll Gate
• Scott’s Pass
• Porus</td><td>Positive</td><td>Long term</td><td>Major</td><td>Reversible</td><td>Encourage housing and commercial development in these communities as a means to help resolve Jamaica’s housing and development needs. This favours Land Use planning objectives for Jamaica.

Exit located at Toll Gate is suited for the area.</td></tr>
</table>

Activities/ Main Issue	Possible Impacts	Possible Impacts				Mitigation Measures
		Direction	Duration	Magnitude	Type	
	Noise and air pollutions rom traffic along the A2 main road, decreases.					
	The highway is regarded as safe when compared with accident reports for the normal road surfaces.	Positive	Long term	Major	Reversible	-
	Highway will contribute to the distribution of income goods and services due to improved travel time for commerce and individual enterprises.	Positive	Long term	Major	Reversible	-
	The Highway will improve travel time and encourage more recreational visits to attractions in Manchester and St. Elizabeth.	Positive	Long term	Major	Reversible	-
Highway extension and Melrose Hill Bypass	Safety of vendors along Melrose Hill Bypass has negative impacts and so the developers plans to relocate these vendors is positive.	Positive	Long term	Major	Reversible	• Relocation of vendors along the Melrose Hill Bypass preferably at the end of the toll road at Williamsfield.
Community impact on highway	Contribution of vehicular traffic on the highway from communities in both Clarendon and Manchester.	Positive	Long term	Major	Reversible	-

6 CUMULATIVE IMPACTS

In addition to both the positive and negative potential impacts identified in Section 6 above, the cumulative impacts have also been identified and are elaborated in Section 6.1 to 6.8 below.

6.1 Road kill

Highways are also major sources of mortality for birds and they can be particularly dangerous for crossing birds when they are elevated above the surrounding terrain. High fencing should be provided as close to the road as possible in such areas to reduce the number of birds crossing the road at low levels and colliding with vehicles. Impacts are most likely where the road bisects good feeding or breeding habitats or migration routes and where the structure of the vegetation is such that birds are likely to be flying over at heights that expose them to collisions. Raptors and owls may also be exposed to extra risk of collisions if the road increases the availability or visibility of prey (such as rats, mice and small birds).

In this case, there are very few birds in the part of the alignment that crosses cane fields, and the risk of collisions is expected to be low. Casual observations of road kills on the existing highway suggest that vulnerable species include Barn Owls *Tyto alba,* Cattle Egrets *Bubulchus ibis,* American Kestrels *Falco sparverius* and Smooth-billed Anis *Crotophaga ani*. These are common in open secondary habitats. However there are many more birds in the uplands and thus an increased risk of collision with a wider range of species. Where the road is in the bottom of a cutting most birds flying over will remain high enough to avoid being hit by traffic however when the road is at the same level or elevated above the surrounding terrain particularly if the area is wooded or forested birds will cross closer to the road surface and the risk of collisions will be significantly greater. The most practical mitigation is to construct highly visible high fences close to the road to force crossing birds to rise above the fencing and hopefully most will remain above the level of traffic as long as the distance between the fences is not too great.

6.2 Fire

Cane and grasslands are subject to fire, both natural and man-made particularly at harvest and in times of drought. Fires could escape and destroy surrounding vegetation.

6.3 Loss of habitats, fragmentation and increased access

The road is likely to have several ecological impacts however the main impacts will be direct loss of habitat, fragmentation and increased access. The corridor of the roadway will be fenced and maintained to exclude all surrounding animals which may create a hazard for high speed vehicles. The road footprint will destroy all the flora and fauna in its path but since it will be restricted to a narrow corridor it will be unlikely to result in significant impact on the population of any of the species in the area since almost all are fairly widespread.

The fragmentation of the surrounding habitats is likely to have a greater long term impact. Many species are vulnerable because of the cumulative loss of suitable habitat. Fragmentation divides the potential habitat into smaller isolated pockets where species cannot freely move between individual parcels or will face increased risk when crossing between pockets of habitats. This results in many problems for wildlife which over time often results in increased mortality of individuals which increases species vulnerability and continuously declining populations.

Roads constructed through pristine habitats often allow people to gain easier access to these areas which results in increased exploitation e.g. hunting and poaching, wood cutting and deforestation and a general increase in the disturbance of the forest in an expanding zone around the road. Since access to the road will be controlled and incursion from the road into the surrounding areas will be limited this may not be a problem locally but the presence of the highway will inevitably result in easier access to locations further away which will become subject to development pressure which if unmanaged will result in uncontrolled conversion of important habitats. As access to more of the country becomes easier it is vital that the government develops secure zoning protection for important habitats. The national system of protected areas and local development plans become more important as access and populations increase.

6.4 Increased Traffic Flow

The data reported in this section was provided to the Consultants by NROCC, and was, in turn, taken from a study undertaken by Stanley Consultants and NWA.

The existing route from May Pen to Williamsfield passes through communities where traffic congestion occurs. The new alignment with the highway design speed will significantly reduce travel time; result in increased efficiency of the movement of goods and services from Kingston through to Mandeville; and save time and money for commuters. This is a long-term cumulative impact as all sections of the highway become complete.

Currently traffic along this section of the highway has been projected to grow at rates shown in Table 6.1 below.

Table 6.1: Traffic Growth Rate of the May Pen–Williamsfield Section

Period	**2016–2020**	**2021–2025**	**2026–2030**	**2031–2035**	**2036–2040**
Growth Rate	4.50%	4.50%	4%	2.80%	1.50%

6.5 Future Traffic Forecast (NROCC)

It is planned that the May Pen–Williamsfield section will commence in 2017 and through the construction period of 30 months be completed and opened to traffic in 2019. Based on the observation data of traffic flow in 2014, the base year for predication of traffic volume is the year of 2014 in this report, the years predicted are 20 years and the characteristic years predicted are the years of 2019, 2025, 2030, 2035 and 2039.

Table 6.2: Annual Average Daily Traffic of May Pen–Williamsfield in the predicted years

Section	2019	2025	2030	2035	2039
May Pen–Clarendon Park Interchange Section	7840	10209	12421	14260	15135
Clarendon Park Interchange to Williamsfield Section	7358	9583	11659	13385	14206
Average traffic volume	7566	9852	11987	13762	14606

6.6 Noise

Noise is likely to be a nuisance to the communities that are more densely populated within close proximity to the highway. This therefore means that the following communities are likely to experience a major noise nuisance if not mitigated appropriately:

- Decoy
- Near Trinity Road

Determination of these areas have already been discussed in Section 5.2.1.4 above.

6.7 Land Use Options

The alignment passes through agricultural lands, pasture, scrublands, residential communities and across existing transportation networks. The land use within these areas are modified by the highway alignment. However, the implementation of the highway will open up access to some previously inaccessible areas, and is likely to result in increased development pressure along the alignment. Targeted land use planning is required to ensure sustainable development options.

In a review of the general alignment, the Jamaican Institute of Engineers (JIE) stated that . . . “The routing for a limited access highway network is self”.

6.8 Employment

The construction phase for the highway is scheduled for 30 months. Various levels of skilled and unskilled labour will be required during the period as well as the provision of goods and services. The other phases of Highway 2000 have created job opportunities, and this would be continued over the short- to medium-term.

7 CONSIDERATION OF ALTERNATIVES

7.1 Alignment and Bauxite Reserves

With its current alignment, the highway will cross territory that contains bauxite reserves for which Jamalco operates a mining lease. This area includes the communities of St. Toolis, Reeves Wood and Redberry. The JBI is concerned that a number of the bauxite reserves will become sterilized given the current path of the proposed highway. In order to limit sterilization of bauxite reserves the following are options:

1) Adjust the alignment to the northeast of its current path in the aforementioned areas so that the larger deposits would not be impacted by the highway.

2) The other alternative would be to extract the deposits before road construction.

The relative feasibility of each option should be considered when discussions are being held between JBI and NROCC to determine the way forward.

7.2 Sourcing of Material

Crushed aggregate from the Rio Minho is a potential source for construction material for the pavement structure of the highway. In the event that the supply of river aggregate is inadequate or does not meet the specific standard, then an alternative source is the Cretaceous volcanics in the Benbow Inlier of St Catherine. This material is skid resistant, meets the specifications for highway construction and was used extensively for the construction of the pavement structure on the recently completed North–South Kingston to Ocho Rios Highway Project. Transportation costs to the project site would be the concern for its use on the May Pen to Williamsfield Highway project.

7.3 Ecological Impacts of Alternatives

There are several possible pathways available for the alignment to cross the lowlands but since most of this area (with the exception of areas close to streams) is of a similar habitat changes of the route in this area would have little difference in overall ecological impact, which should be relatively low considering the high levels of disturbance.

When entering the limestone uplands i.e. from Clarendon Park to Williamsfield, there appear to be three possible alternatives:

a. The route proposed in 2007
b. The current alignment to the south of the original line
c. An alignment further south

The 2007 alignment would run through the Porus valley and would pass through more areas that are small holdings and varied cultivation. It would appear that based on the levels of cultivation and settlement observed that the 2007 alignment would have resulted in dislocation of more settlements in relation to the current proposed route. Additionally, the new alignment passes through a small area of limestone woodland as it leaves Clarendon Park heading west up a steep limestone escarpment. It appears that this particular zone had the lowest level of disturbance observed along the entire route. This was likely due to its steep and rocky terrain and poor soils, which are unsuitable for cultivation. Beyond the escarpment (continuing west), the route is less steep and has more soils and as a result the human disturbance increases.

If the alignment crosses the escarpment much further south it will again encounter high levels of disturbance including bauxite mining and transportation activities. The remaining forested areas are highly fragmented and this disturbance may have already reduced the ecological value of the area. Further examination will be required to characterize the levels of disturbance.

An alignment passing through the limestone upland further to the north of the original proposed route might traverse very steep terrain which appears to be well forested with low levels of disturbance. Such a route is likely to result in the highest ecological impact of all the options under consideration and given the additional cost of construction in steep terrain this option might be the least suitable.

7.4 No Action Alternative

Similarly with the 'No Action Alternative' of the original EIA in 2007, this examines the option of not constructing Phase 1C of the highway 2000 alignment. This would break the continuity of the alignment that has been completed from the Portmore Causeway through Bushy Park and to Sand Bay, which is expected to be eventually linked from Williamsfield to Montego Bay.

8 OUTLINE MONITORING PROGRAMME AND ENVIRONMENTAL MANAGEMENT PLAN

Monitoring is important to reduce the negative environmental issues. If a permit is granted for the realignment of the highway May Pen to Williamsfield, a full Monitoring Plan should be prepared and submitted for the approval of NEPA. This Monitoring Plan is expected:

- Comply with relevant legislation
- Ensure implementation of the mitigation measures provided
- Conform with any General or Specific Conditions of the environmental permit when recevied
- Guide long-term minimization of negative environmental impacts.

Similar to the Monitoring Plan Outline of the EIA completed in 2007 for the original alignment, the following components need to be included:

1. Inspection protocol
2. Parameters to be monitored, which should include
    - Ambient air quality
    - Water quality
    - Perimeter noise
3. Construction monitoring
    - Worker health and safety
    - Disposal of solid waste
    - Disposal of hazardous material
    - Disposal of liquid waste
    - Draining and rehabilitation of sewage pond
4. Materials handling and storage

5. Covering of haulage vehicles
6. Transportation of construction materials
7. Deployment of flaggers and signposting
8. Storage of fines and earth materials

The Monitoring Plan should speak to the entire construction period, with monthly reporting.

It is not possible to prepare a full Monitoring Plan at this stage, given that fact that a permit has not yet been granted by NEPA. The Monitoring Plan will need to take into consideration all the necessary Terms and Conditions placed in the environmental permit issues by NEPA.

The Environmental Management Plan should also be prepared after the permit is issued and the general and specific terms and conditions are known. The Environmental Management Plan should take into account, but not be limited to the following aspects

- Solid waste management
- Liquid waste management
- Resource efficiency
- Hazard materials management
- Accident and emergency response
- Environmental management systems

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APPENDIX I – TERMS OF REFERENCE

The Consultants have been presented with terms of reference for the realignment of Highway 2000 East-West, Phase 1C: May Pen to Williamsfield. It is important to note that important sections of the current alignment coincide closely with sections of an earlier alignment for which an EIA permit has already been granted. In these locations, both alignments traverse a generally common physical, ecological and socioeconomic environment, which can be characterized as experiencing little direct impact on critical ecological features, settlement or economic activity. This TOR represents the agreed TOR based on discussion between NEPA and NROCC.

As extracted from the terms of reference received, the expectations of the Consultants are presented below.

Provide a comprehensive description of the project, noting areas to be reserved for construction and verges. The description of the project will give the total length of the alignment, the width of the right-of-way, width of verges, drainage requirements, bridges and crossings and the location of toll plazas. This will also include an account of activities and features, which will introduce risks or generate impacts (negative and positive) on the environment. This may include secondary activities, such as, fuel dispensing stations, concrete batching plants and camp sites with the various auxiliary activities. This will involve the use of maps, site plans, aerial photographs and other graphic aids and images, as appropriate, and include information on location, general layout and size, as well as pre-construction, construction, and post-construction plans.

Descriptions are also expected of the following:

Project related Issues:

1. *Methods and location of construction surplus material disposal*
2. *Any changes to associated water diversion management system*
3. *The proposed off-site facilities, such as construction camps and infrastructure service*
4. *Proposed decommissioning and abandonment of works and/or facilities*
5. *Public Health and Safety as well as workers' health and welfare*
6. *Possible source of material for road fill and likely impacts burrowing, excavation and embankment fill can have on biological, socioeconomic and physical environment.*

Description of the Environment:

Review existing data from Strategic Environmental Assessment (SEA) (2000) and to generate an overall evaluation of the existing environmental conditions, values and functions in physical, biological, cultural and socioeconomic environment.

The information to be presented should include the following:

Physical

- *Review of Geotechnical Studies of the areas between Km 48+000+/- and 67+000+/- and provide recommendations to address long-term slope stability both in the fill and cut areas. Emphasis must be placed on geological faults and any other geological structure vis-à-vis fracture plains and orientation bedding;*
- *Identification of old landslides on or in close proximity to the highway route;*
- *Reference will be made to future development of lands. Special emphasis should be placed on stormwater run-off and drainage patterns. Any slope stability issues that could arise will be thoroughly explored;*
- *Assessment of climatic conditions and air quality in the area of influence including particulate matter, NOx, SOx, wind speed and direction, precipitation, relative humidity and ambient temperatures.*
- *Conduct an assessment of the ambient noise conditions to determine the predicted noise impact from the construction and operation of the tolled road and locations near residences of other sensitive receptors. Assessments should be conducted for at least seventy-two (72) hours;*
- *Assessment of ambient air quality baseline conditions for areas along the corridor measuring coarse and airborne pollutants that fall between 2.5 and 10 micrometres in diameter. Measurement should be collected for at least twenty-four (24) periods and matched against NEPA and other international standards. Assess for potential residual air quality impact;*
- *Identify and assess the impact of the project on potential wells, ground water during the pre-construction, construction, and post-construction phases and its associated effect on water supplies to the adjacent communities.*

Drainage and Stormwater Issues:

1. *Evaluate drainage studies previously conducted for the Highway 2000 Project, including, but not limited to the following:*

    - *Flood Risk Management along the Highway 2000 Corridor (2012);*
    - *Drainage and Hydrology Report Volume I & II, Highway 2000 Project Preliminary Design Phase;*
    - *Final Bridge Hydraulic Report Highway A2 over Rio Minho (January 2013);*
    - *Flood Risk Management along Highway 2000 corridor – Rainfall analysis (August 2011);*
    - *Evaluate drainage for the site during construction and operation to include mitigation for erosion and sediment control;*
    - *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;*
    - *Assessment of the impact of draining the site on adjacent communities and on future developments including mitigation measures. This should be calculated and designed to facilitate the storm runoff without causing flooding of these development. Underpasses*

for the highway should be designed to accommodate the volume and velocity of stormwater in the post-construction period;

- *Assessment of drainage channels for debris flow associated with up gradient land use as well as impacts related to climate change;*
- *Assess the use of detention ponds to regulate peak flow;*
- *Identify and clearly map locations of sinkholes based on Water Resources Database, to ensure that, where necessary, these are not traversed by the highway alignment;*
- *Identify other effects of stormwater such as the input of oil and grease into the aquatic environment.*

Biological

2. *Review biological data from previous studies to include, but not limited to:*
   i. *Strategic Environmental Assessment (DESSAU, 2000);*
   ii. *Environmental Impact Assessment, Highway 2000, Sandy Bay Williamsfield (2007).*

Conduct a rapid ecological assessment for the section between km 48+000+/- and Km 60+000 +/-. In addition, present an assessment of the flora and fauna of the area, with special emphasis on rare, endemic, protected or endangered species. Migratory species will also be considered. Information will be presented on existing vegetation, proposed vegetation loss and resulting loss and/or fragmentation of habitat for fauna. Generally, species dependence, niche specificity, community structure and diversity will be considered.

Socioeconomic and Cultural

3. *Review aspects of the Corridor Development Plan and prepare a Socioeconomic Analysis that will include present and projected populations; present and proposed land use; planned development activities, issues relating to squatting and resettlement, community structure, employment, distribution of income, goods and services; recreation; public health and safety; and community health, health facilities and medical services. in addition, cultural peculiarities, aspirations and attitudes should be explored.*

   The historical importance of the area should also be examined, augmented by consultation with the Jamaica National Heritage Trust (JNHT). While this analysis is being conducted, an assessment of public perception of the proposed development will be conducted.

Legal and Regulatory Considerations

4. *Outline the pertinent regulations and standards governing environmental quality, safety and health, protection of sensitive areas, protection of endangered species, siting and land use control at the national and local levels. The examination of the legislation should include at minimum, legislation such as the NRCA Act, the Public Health Act, the Town and Country*

Planning Act, the Toll Roads Act, the Main Roads Act, and the appropriate international convention/protocol/treaty where applicable.

Identification of Impacts

5. *Identify the major physical, environmental, biological and social issues of concern and indicate their relative importance to the development project. The assessment will identify relevant significant positive and negative impacts, direct and indirect, long-term and immediate impacts. Identify avoidable as well as irreversible impacts.*

Characterize the extent and quality of the available data, explaining significant information deficiencies and any uncertainties associated with the predictions of impacts. Take note of the fact that a major environmental issue is determined after examining the impact (positive and negative) on the environment and having the negative impact significantly outweigh the positive. It is also determined by the number and magnitude of mitigation strategies which need to be employed to reduce the risk(s) introduced to the environment.

Environmental Management and Mitigation

6. *Prepare guidelines for avoiding, as far as possible, (e.g., restoration and rehabilitation) any adverse impacts due to the proposed development of the highway corridor and utilizing existing environmental attributes for optimum development. Quantify and assign financial and economic values to mitigating methods. These guidelines should include the issues of restoration and rehabilitation during construction and operation.*

An Environmental Management Plan and Historic Preservation Plan (if necessary) for the long-term operations of the site will also be prepared. An outline for an Environmental Monitoring Programme (EMP) for the construction phase will be prepared, indicating the parameters to be monitored, and the recommended frequency of monitoring. A detailed version of the EMP will be submitted to NEPA for approval after the granting of the permit and prior to the commencement of the development.

Project Alternatives

7. *Examine alternatives to the project including the no-action alternative. This examination of project alternatives will incorporate the history of the overall area in which the site is located and previous uses of the area itself.*

Public Participation/Consultation Programme

8. *A Public Presentation on the findings of the Environmental Report will be conducted to inform, solicit and discuss comments from the public, on the proposed project. Considering the geographical scope of the project, at least two consultations are recommended, one in Clarendon, and the other in the Manchester. All findings will be presented in the EIA Report and*

will reflect the headings in the body of the TORs. Information and data presented will be supported by references. The required hard copies and an electronic copy of the report will be submitted to NEPA, as required by the environmental regulations. The report will include an appendix with items such as maps, site plans, the study team, terms of reference, photographs, and other relevant information. Key stakeholders to be consulted will be identified and the mechanisms for consultation and disclosure of the project, from the project design to the operational phase, will be given.

APPENDIX II– WATER QUALITY ANALYTICAL TECHNIQUES

Environmental Solutions Limited (ESL) Laboratory analyzed or supervised the analysis of all parameters. All the methods used in the ESL lab are approved standard methods.

Meter Readings (Conductivity, TDS, pH, Salinity, Dissolved Oxygen)

Sampling/Method Used:

No sample will be collected for these parameters. To ensure that the values represent the actual environment, these will be done in the field using a calibrate Multimeter.

Turbidity

Sampling

Turbidity measurement can be performed in situ and/or a sample collected in a clean Polyethylene bottle or glass bottle. The temperature of the sample was lowered to $4^{O}C$ using an ice filled igloo. The sample upon reaching the laboratory was analysed immediately.

Method Used

Nephelometric Method: Turbidity is measured using a turbidity meter or Nephelometer. This device has a detector which measures the intensity of the scattered light at 90° angle to a beam of light passing through a water sample. Turbidity is measured in Nephelometric Turbidity Units (NTU).

Phosphates

Sampling

Samples are collected in clean pretreated Polyethylene or glass bottles. Samples are analyzed immediately after collection, to preserve samples for up to 48 hours if the samples are filtered immediately and stored at 4 ^{O}C.

Method Used

PhosVer 3(Ascorbic Acid) Method: Orthophosphate reacts with molybdate in an acidic medium to produce a phosphomolybdate complex which in turn is reduced by ascorbic acid to form a blue coloured analyte which is read by a spectrophotometer as mg/L Phosphates.

Nitrates

Sampling

Samples are collected in clean Polyethylene or glass bottles. The samples are analysed as soon as possible or can be stored at 4 ^{O}C or lower for 2 days. With treatment by sulfuric acid to a pH of less than 2 the samples can be stored up to 14 days.

Method Used

Cadmium Reduction Method: Cadmium metal reduces nitrates present in the sample to nitrite. The nitrite ions reacts in an acidic medium with sulphanilic acid to form an intermediate diazonium salt. This salt couples to gentisic acid to form an intermediate diazonium salt. This salt couples to gentisic acid to form an analyte whose concentration is read as mg/L nitrate by a spectrophotometer.

Chloride

Sampling

Samples for chlorine are collected into clean glass or Polyethylene bottles. The samples are analyzed as soon as possible but can be stored up to 7 days at temperatures at or below 4 ^{O}C.

Method Used

HACH Mercuric Nitrate Method: The sample is titrated under acidic conditions using a standardized Mercuric Nitrate solution and Diphenylcarbazone indicator. At the reaction end point the indicator forms a pink-purple complex with excess mercuric ions. The concentration of chloride in the sample in mg/L is calculated from volume of titrant used

Total Coliforms

Sampling

Samples are collect in special coliform glass bottles. These containers are pretreated before collection of samples and kept sterile until sample collection. Samples are analyzed as soon as possible with the 6 hours at 4 ^{O}C holding time in perspective.

Method Used

Most Probable Number: Shake the sample to ensure homogeneity and sanitize the container by wiping it with a clean paper towel saturated with 70% alcohol. Inoculated Lauryl Tryptose Broth with required sample volume and incubated at 35°C for 48 hours. Following incubation all tubes showing growth, acid and or gas production is recorded and submitted to the confirmatory test. To confirm Total Coliforms, Brilliant Green Bile Broth is inoculated and incubated with test sample at 35.5 +/- 0.5°C for 48 hours. Gas production of any quantity in the inverted tube constitutes a positive test. The MPN value is then calculated using the MPN Tables.

Faecal Coliforms

Sampling

Samples are collect in special coliform bottles or bags. These containers are pre-treated before collection of samples and kept sterile until sample collection. Samples are analysed as soon as possible with the 6 hours at 4 ^{O}C holding time in perspective.

Method Used

Most Probable Number (SM 9221): The sample is *s*haken to ensure homogeneity and the container sanitized by wiping it with a clean paper towel saturated with 70% alcohol. Inoculated Lauryl Tryptose Broth with required sample volume and incubated at 35°C for 48 hours. Following incubation all tubes showing growth, acid and or gas production is recorded and submitted to the confirmatory test. To confirm Faecal Coliforms, EC Broth is inoculated and incubated at 44.5 +/- 0.2°C for 24 hours. Gas production of any quantity in the inverted tube constitutes a positive test. The MPN value is then calculated using MPN Tables.

Biological Oxygen Demand (BOD_5)

Sampling

Sampling for BOD samples is done using special BOD (amber glass/polyethylene) sample bottles. Samples are analyzed as soon as possible but can be stored for 24 hours at 4 ^{O}C or colder. Special sampling procedures must be adhered to.

Method Used

HACH BODTrack Method: This BOD method measures the amount of oxygen used by bacteria as they oxidized organic matter in the sample. The sample is placed in BODTrack bottles with an ample amount of air left above the sample. As the bacteria use the dissolve oxygen in the sample it releases carbon dioxide which is absorbed by a hydroxide causing a drop in the pressure above the sample which is read as milli-gram per litre BOD.

Chemical Oxygen Demand

Sampling

COD samples are collected in glass bottles and plastic bottles are used only if they are known to be free of organic contamination. Samples containing solids are homogenized. Samples should be analysed as soon as possible but after treatment with sulfuric acid to a ph of less than 2 can be stored up to 28 days at 4 ^{O}C.

Method Used

Reactor Digestion Method: The mg/L COD is defined as the mg of O_2 consumed per litre of sample under the conditions of the method used. The sample is heated for a period of time with a strong oxidizing agent. Oxidizable organic compounds react, reducing the oxidizing agent. A colorimetric measurement is then used to determine the amount of oxidizing agent remaining which determines the amount of oxygen consumed.

Total Suspended Solids

Sampling

Samples for total suspended solids are collected in clean high density Polyethylene bottle or glass bottles. Samples are analyzed as soon as possible but can be stored for seven days by cooling to 4 ^{O}C.

Method Used

Gravimetric Method (SM 2540-D): The determination of TSS is done by filtering a measured volume of sample under vacuum using 0.45 µm membrane or glass fibre filters which has been preconditioned. The residue on the filter is dried to constant weight in an oven set at between 103 -105 ^{o}C. The difference in weight between the final filter weight and the preconditioned weight divided by the volume of sample filtered gives the concentration of suspended sediments in the sample.

Fats, Oils and Grease

Sampling

Samples are collected in wide-mouth glass bottles. If analysis is delayed for more than four hours the sample pH is adjusted to less than 2 using sulphuric or hydrochloric acid and store at 4 ^{O}C.

Method Used

Partition Gravimetric Method: Sample is acidified and the oils are extracted using one of the approved extraction methods (sohxlet, N-Hexane etc.). The extraction is concentrated and then gravimetrically treated. The amount of FOG present is then determined from the sample volume used.

Metals

Sampling

Samples are collected in a cleaned polyethylene or glass bottle. The samples are acidified with nitric acid until their pH is 2 or less. Samples can be stored up to six months using this method.

Method Used

Atomic Absorption Spectroscopy: The sample is first digested using a mixture of acids over a hotplate. After digestion the sample's pH is increased to between 4-6 and the sample diluted. The metal concentration is then determined using Atomic Absorption Spectroscopy

Pesticides

Sampling

Two (2) to Four (4) litres of sample are collected in a precleaned amber glass bottle. Samples are analysed within 24hrs of collection but may be preserved by reducing the pH of the sample to <2 using hydrochloric acid.

<u>Method Used</u>

Gas chromatography: samples are injected into a heated port and are volatilized. The samples are carried in the gaseous phase by an inert carrier gas and are separated based on their polarity along the column which is coated with the stationary phase. The components of the sample are detected and identified (and quantified) by comparing it to standards used during the analysis.

Total Petroleum Hydrocarbon (TPH)

<u>Sampling</u>

Water Samples

Water samples are collected in one (1) litre amber glass bottles containing sulphuric acid to ensure the pH of the collected sample is less than 2. Samples are stored at 4° C and are analyzed within 7 days.

<u>Method Used</u>

EPA 1664: Sample is acidified and the oils are extracted using one of the approved extraction methods (sohxlet, N-Hexane etc.). The extract IS treated with silicia to remove the polar organic material. The resulting extract is then concentrated and gravimetrically treated. The concentration of TPH present is then determined from the sample volume used.

APPENDIX III – NOISE METRE CALIBRATION CERTIFICATE

3M Personal Safety Division

3M Oconomowoc
1060 Corporate Center Drive
Oconomowoc, WI 53066-4828
www.3M.com/detection
800 245 0779

Page 1 of 2

3M

Certificate of Calibration

Certificate No: 5517081QII050083

Submitted By: C.L. ENVIRONMENTAL CO

22 FORT GEORGE HEIGHTS, OLD STONY HILL RD, KINGSTON 9, JAMAICA

Serial Number: QII050083 — Date Received: 4/1/2016

Customer ID: — Date Issued: 4/1/2016

Model: QC-10 CALIBRATOR — Valid Until: 4/1/2017

Test Conditions:

Temperature: 18°C to 29°C
Humidity: 20% to 80%
Barometric Pressure: 890 mbar to 1050 mbar

Model Conditions:

As Found: IN TOLERANCE
As Left: IN TOLERANCE

SubAssemblies:

Description: **Serial Number:**

Calibration Procedure: 56V981

Reference Standard(s):

I.D. Number	Device	Last Calibration Date	Calibration Due
ET0000556	B&K ENSEMBLE	4/8/2015	4/8/2016
T00230	FLUKE 45 MULTIMETER	2/4/2016	2/4/2018

Measurement Uncertainty:

+/- 1.1% ACOUSTIC (0.1DB) +/- 1.4% VAC +/- 0.012% HZ
Estimated at 95% Confidence Level (k=2)

Calibrated By: Bryan Rasmussen — 4/1/2016
BRYAN RASMUSSEN, Service Technician

Reviewed/Approved By: Paul M. Wegmann — 4/1/2016
Technical Manager/Deputy

This report certifies that all calibration equipment used in the test is traceable to NIST or other NMI, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of 3M Detection Solutions.

098-393 Rev. B

An ISO 9001 Registered Company
ISO 17025 Accredited Calibration Laboratory

A2LA ACCREDITED Calibration Laboratory CERT#1326.01

APPENDIX IV – SPECIES LISTS

Table 1: Plant list for May Pen to Williamsfield

Family	Common Name	Scientific Name	Growth habit	Provenance	Disturbed dry limestone woodland	Roadside scrub	Rural settlement and cultivation	Pasture and canefields
Acanthaceae	Asystasia	*Asystasia gangetica*	Scrambler	Introduced		o	o	
Acanthaceae	Duppy Gun	*Ruellia tuberose*	Herb	Native	c	o		o
Acanthaceae	White Nightshade	*Thunbergia fragrans*	Vine	Introduced		o		o
Acanthaceae		*Blechum pyramidatum*	Herb				o	
Agavaceae	Coratoe, MayPole	*Agave sobolifera*	Shrub	Native	o	o	o	
Agavaceae	Sisal	*Agave sisalana*		Introduced	o			
Amaranthaceae	Calaloo	*Amaranthus viridis*				o		o
Amaranthaceae	Crab Withe	*Alternanthera ficoidea*						
Amaranthaceae	Devil's horse whip	*Achyranthes indica*	Herb	Native		o	o	o
Amaryllidaceae	Unidentified species						o	
Anacardiaceae	Burnwood	*Metopium brownie*	Large tree	Native	o	o	o	
Anacardiaceae	Cashew	*Anacardium occidentale*		Native			o	o
Anacardiaceae	Hog Plum	*Spondias mombin*	Large tree	Native			o	
Anacardiaceae	Jamaican Plum	*Spondias purpurea*					o	
Anacardiaceae	June Plum, Jew Plum	*Spondias dulcis*					o	
Anacardiaceae	Maiden Plum	*Commocladia pinnatifolia*	Small tree	Native	o		o	

Family	**Common Name**	**Scientific Name**	**Growth habit**	**Provenance**	**Disturbed dry limestone woodland**	**Roadside scrub**	**Rural settlement and cultivation**	**Pasture and canefields**
Anacardiaceae	Mango	*Mangifera indica*	Large tree	Introduced			f	o
Annonaceae	Black Lancewood	*Oxandra lanceolata*	Small tree	Native				
Annonaceae	Custard Apple	*Annona reticulate*	Small tree	Native			f	
Annonaceae	Soursop	*Annona muricata*	Small tree	Introduced			f	
Annonaceae	Sweetsop	*Annona squamosa*	Small tree	Native			f	
Apocynaceae	Frangipani	*Plumeria obtuse*	Shrub	Native	o		o	
Apocynaceae	Lucky Nut	*Thevetia peruviana*	Tree	Introduced			o	
Apocynaceae	Nightshade	*Urechites lutea*	Vine	Native	f	o		o
Apocynaceae	Oleander	*Nerium oleander*				o	o	
Araceae	Coco	*Xanthosoma sagittifolium*						
Araceae	Five Finger	*Syngonium auritum*	Vine	Introduced		o	f	
Asclepiadaceae	Butterfly Bush	*Asclepias curasavica*	Herb	Native		o		o
Bignoniaceae	African Tulip	*Spathodea campanulata*	Large tree	Introduced		o	f	o
Bignoniaceae	Calabash	*Crescentia cujete*	Small tree	Native	o	o	f	o
Bignoniaceae	Torchwood	*Tecoma stans*	Shrub	Native	f	a	o	o
Bignoniaceae	Yellow Poui	*Tabebuia rufescens*					o	
Binoniaceae	Water Oak	*Catalpa longissumum*	Large tree	Native		a	o	
Bombaceae	Silk Cotton	*Ceiba pentandra*	Large tree	Native	o	o	o	o
Boraginaceae	Clammy Cherry	*Cordia collococca*	Tree	Native		o	o	
Boraginaceae	Duppy Cherry	*Cordia alba*	Tree	Native		o	o	
Boraginaceae	Scorpionweed	*Heliotropium indicum*	Herb	Native		o		o
Boraginaceae	Spanish Elm	*Cordia gerascanthus*	Large tree	Native		o	o	

Family	Common Name	Scientific Name	Growth habit	Provenance	Disturbed dry limestone woodland	Roadside scrub	Rural settlement and cultivation	Pasture and canefields
Bromeliaceae	Tillandsia	*Tillandsia recurvata*	Epiphyte	Native	f		o	o
Bromeliaceae	Tillandsia	*Tillandsia setacea*	Epiphyte	Native			o	
Burseraceae	Red Birch	*Bursera simarouba*	Large tree	Native	o	o	o	
Cactaceae	Mistletoe	*Rhipsalis baccifera*	Epiphyte	Native		o	o	
Cactaceae	Prickle With	*Hylocereus triangularis*	Climbing cactus	Endemic		o	o	
Caesalpiniaceae	Bull Hoof	*Bauhinia divaricata*	Small tree	Native	o	o		
Caesalpiniaceae	Dandelion	*Cassia occidentalis*						
Caesalpiniaceae	King of the forest	*Cassia alata*						
Caesalpiniaceae	Logwood	*Haemotoxylon campechianum*	Small tree	Introduced	d	a		o
Caesalpiniaceae	Poinciana	*Delonix regia*	Large tree	Introduced	f	f	o	o
Caesalpiniaceae	Tamarind	*Tamarindus indica*	Large tree	Introduced			o	
Caesalpiniaceae	Yellow Candlewood	*Cassia emarginata*	Shrub	Native	o	o		o
Capparidaceae	Wild Caia	*Cleome viscose*	Herb	Introduced	a	o		
Caricaceae	Papaya, Papaw	*Carica papaya*				o	f	
Cassuarinaceae	Cassuarina	*Cassuarina equiseltfolium*	Large tree	Introduced			o	
Combretaceae	Almond	*Terminalia catappa*	Large tree	Introduced			o	
Combretaceae	Broadleaf	*Terminalia latifolia*	Large tree	Native		o	o	
Commelinaceae	Moses in the Cradle	*Rhoeo spathacea*	Herb	Introduced		o		
Commelinaceae	Water grass	*Commelina diffusa*	Herb	Native		o	o	o
Commelinaceae	Water grass	*Commelina elegans*	Herb	Native		o	o	o

Family	**Common Name**	**Scientific Name**	**Growth habit**	**Provenance**	**Disturbed dry limestone woodland**	**Roadside scrub**	**Rural settlement and cultivation**	**Pasture and canefields**
Compositae	Bitterbush	*Eupatorium villosum*	Shrub	Native		o		o
Compositae	Cupids Shaving Brush	*Emilia javanica*	Herb	Native		o		o
Compositae	Marygold	*Wedelia trilobata*	Herb	Native			o	o
Compositae	Old Woman's Bitter Bush	*Eupatorium triste*	Shrub					o
Compositae	Quacko Bush	*Mikania micrantha*	Vine	Native	f	o	o	o
Compositae	Spanish Needle	*Bidens pilosa*	Herb	Native		f		o
Compositae		*Spilanthes sp*	Herb					o
Compositae		*Tridax procumbens*	Herb	Native				
Convolvulaceae	Love Bush	*Cuscuta Americana*	Vine	Native	o	o	o	o
Convolvulaceae	Wild Potato, Wild Slip	*Ipomoea tiliaceaea*	Vine	Native	f	o		
Convolvulaceae		*Ipomoea spp.*			f		o	
Cucurbitaceae	Cerasee	*Momordica charantia*			f	o	o	o
Cyperaceae	Reed	*Eleocharis elegans*		Native				
Cyperaceae	Reed	*Eleocharis mutate*		Native				
Cyperaceae	Sedge	*Fimbristylis dichotoma*	Sedge	Native				
Cyperaceae		*Scleria lithosperma*	Sedge	Native				
Cyperaceae		*Cyperus spp.*						
Euphorbiaceae	Belly-ache bush	*Jatropha gossypiifolia*	Herb	Native				o
Euphorbiaceae	Castor Oil	*Ricinus communis*	Shrub	Introduced		f	o	o

Family	Common Name	Scientific Name	Growth habit	Provenance	Disturbed dry limestone woodland	Roadside scrub	Rural settlement and cultivation	Pasture and canefields
Euphorbiaceae	Cassava	*Manihot esculenta*	Shrub	Introduced			f	f
Euphorbiaceae	Dovewood, Lablab Tree	*Alchornea latifolia*	Small tree	Introduced		o		
Euphorbiaceae	Pepper Rod	*Croton humilis*	Herb	Native		o		
Euphorbiaceae	Rosemary	*Croton linearis*	Shrub	Native	f			
Euphorbiaceae		*Jatropha integerrima*	Shrub					
Fabaceae	Donkey Weed	*Stylosanthes hamata*	Herb	Native	f	o		o
Fabaceae		*Teramnus labialis*	Vine	Native				
Gesneriaceae	Search-me-heart	*Rytidophyllum tomentosum*	Shrub	Endemic		a	o	
Gramineae (Poaceae)	Napier Grass	*Pennisetum purpureum*	Grass	Introduced		f	o	
Guttiferae	Balsam Fig	*Clusia flava*	Scrambler	Native			o	
Labiatae	Christmas Candlestick	*Leonotis nepetifolia*	Herb	Introduced		f	o	f
Lauraceae	Sweetwood	*Octea spp.*	Tree	Native		o	o	
Leguminosae	Stinking Pea	*Senna bicapsularis*			f			o
Liliaceae	Mother in Law's Tongue	*Sansevieria metallicia*	Herb	Introduced	o		f	
Lythraceae	Crape Myrtle	*Lagerstromemia indica*	Shrub	Introduced		o	o	
Lythraceae		*Ammannia sp.*	Shrub	Native				
Malpighiaceae	Hogberry	*Byrsonima coriacea*	Tree	Native		o		

Family	**Common Name**	**Scientific Name**	**Growth habit**	**Provenance**	**Disturbed dry limestone woodland**	**Roadside scrub**	**Rural settlement and cultivation**	**Pasture and canefields**
Malpighiaceae	West Indian Cherry	*Malpighia punicifolia*	Small tree	Introduced			**o**	
Malvaceae	Blue Mahoe	*Hibiscus elatus*	Large tree	Native			o	
Malvaceae	Broomweed	*Sida acuta*	Herb	Native		o		
Malvaceae	Congo Mahoe	*Hibiscus clypeatus*	Shrub	Native				
Malvaceae		*Abutilon trisulcatum*	Herb	Introduced				
Malvaceae		*Pavonia sp.*	Herb	Undetermined				
Malvaceae		*Sida ciliaris*	Herb	Native		o		
Malvaceae		*Sida paniculata*	Herb	Introduced		o		
Melastomaceae		*Miconia sp.*	Shrub			o		
Meliaceae	West Indian Cedar	*Cedrela odorata*	Large tree	Native		f	o	
Meliaceae	West Indian Mahogany	*Swietenia mahagoni*	Large tree	Native		o	o	
Menispermaceae	Velvet leaf	*Cissampelos pareira*	Vine	Native		o		
Mimosaceae	Guango	*Samanea saman*	Large tree	Native		a	f	o
Mimosaceae	Lead Tree	*Leucena leucocephala*	Small tree	Native	a	a	o	o
Mimosaceae	Privet, Bread & Cheese	*Pithecellobium unguis-cati*			o	o	o	
Mimosaceae	Shame-me-lady	*Mimosa pudica*	Herb	Native		f	o	
Mimosaceae	Wild Popanax	*Acacia tortuosa*	Small tree	Native	o			o
Mimosaceae	Wild Tamarind	*Pithecellobium arboretum*	Large tree	Native		o	o	
Moraceae	Breadfruit	*Artocarpus altilis*	Large tree	Introduced			f	

Family	Common Name	Scientific Name	Growth habit	Provenance	Disturbed dry limestone woodland	Roadside scrub	Rural settlement and cultivation	Pasture and canefields
Moraceae	Cherry Fig	*Ficus Americana*	Tree	Native		o		
Moraceae	Fig tree	*Ficus citrifolia*	Tree	Native		o	o	
Moraceae	Jackfruit	*Artocarpus heterophyllus*	Tree				o	
Moraceae	Ramoon	*Trophis racemosa*	Large tree	Native				
Moraceae	Trumpet Tree	*Cecropia peltata*	Tree	Native	o	f	o	
Myrsinaceae		*Ardisia compressa*	Tree	Endemic				
Myrtaceae	Guava	*Psidium guajava*	Small tree	native	o	f	o	
Myrtaceae	Otaheite Apple	*Syzygium malaccense*	Large tree	Introduced			o	
Myrtaceae	Pimento	*Pimenta dioica*	Large tree	Native		o	o	
Myrtaceae	Rodwood	*Eugenia axillaries*	Tree	Native		o	o	
Myrtaceae	Rose Apple	*Syzygium jambos*	Large tree	Introduced		o	o	
Myrtaceae		*Eugenia spp.*				o		
Nyctaginaceae	Bougainvillea	*Bougainvillea glabra*	Scrambler	Introduced		o	o	
Nyctaginaceae	Wait-a-bit	*Pisonia aculeate*	Scrambler	Native	o	f	o	
Orchidaceae		*Broughtonia sanginea*	Epiphyte	Native	o		r	
Orchidaceae		*Oncidium sp.*	Epiphyte	Native	r		r	
Orchidaceae	Cockleshell Orchid	*Encycliafrangrans*	Epiphyte	Native			r	
Palmae	Broom Thatch	*Thrinax parviflora*	Small tree	Endemic	f			
Palmae	Coconut	*Cocos nucifera*	Tree	Introduced		o	f	
Palmae	Royal Palm	*Roystonea altissima*	Large tree	Endemic		o	o	
Papaveraceae	Celandine	*Bocconia frutescens*	Shrub	Native		o	o	
Papaveraceae	Mexican Poppy	*Argemone mexicana*	Herb	Native	f	o		

Family	**Common Name**	**Scientific Name**	**Growth habit**	**Provenance**	**Disturbed dry limestone woodland**	**Roadside scrub**	**Rural settlement and cultivation**	**Pasture and canefields**
Papilionaceae	Blue Rattleweed	*Crotalaria verrucosa*	Herb	Native				o
Papilionaceae	Cabbage Bark Tree	*Andira inermis*	Tree	Native	o			
Papilionaceae	Dogwood	*Piscidia piscipula*	Large tree	Native	o	o	o	
Papilionaceae	Duppy Machete	*Erythrina corallodendrum*	Small tree	Native			o	o
Papilionaceae	Jamaica Ebony	*Brya ebenus*	Tree	Native	o			o
Papilionaceae	Medina	*Alysicarpus vaginalis*	Herb					
Papilionaceae	Quick stick	*Gliricidia sapida*	Small tree	Introduced	f	f	o	o
Papilionaceae	Rattleweed	*Crotolaria retusa*	Shrub	Native				
Papilionaceae	Wild Hops	*Moghania strobilifera*	Shrub	Introduced	o	o		o
Papilionaceae		*Galactica pendula*	Climber	Endemic				
Papilionaceae		*Lonchocarpus latifolius*	Large tree	Native			o	
Papilionaceae		*Erythrina variagatum*	Small tree	Introduced			o	
Papilionaceae		*Centrosema virginianum*	Vine	Native				
Passifloraseae	Sweet Cup	*Passiflora maliformis*						
Phytolaccaceae	Dogberry	*Rivina humilis*						o
Phytolaccaceae	Guinea Hen Weed	*Petiveria alliacea*						o
Phytolaccaceae		*Phytolacca icosandra*	Herb	Native				
Piperaceae	Black Jointer	*Piper alamago*	Small tree	Native	o		o	o
Piperaceae		*Pothomorpha umbellate*	Herb	Native			o	
Plumbaginaceae		*Plumbago scandens*					o	
Poaceae (Gramineae)	African Star Grass	*Cynodon nlemfuensis*						o

Family	Common Name	Scientific Name	Growth habit	Provenance	Disturbed dry limestone woodland	Roadside scrub	Rural settlement and cultivation	Pasture and canefields
Poaceae (Gramineae)	Bamboo	*Bambusa vulgaris*	Small tree	Introduced	**o**	**o**	***o***	
Poaceae (Gramineae)	Bermuda/ bahama grass	*Cynodon dactylon*					***o***	**o**
Poaceae (Gramineae)	Corn grass	*Setaria barbata*		native				**o**
Poaceae (Gramineae)	Grass	*Chloris barbata*	Grass	Native				**o**
Poaceae (Gramineae)	Grass	*Dactyloctenium aegyptium*	Grass	Native				**o**
Poaceae (Gramineae)	Guinea Grass	*Panicum maximum*					***o***	**f**
Poaceae (Gramineae)	Natal Grass	*Rhychelytrum repens*	Grass	Introduced				**o**
Poaceae (Gramineae)	Piano Grass	*Themeda arguens*	Grass	Introduced				o
Poaceae (Gramineae)	Seymour Grass	*Andropogon pertusus*	Herb	Native				o
Poaceae (Gramineae)	Yard grass	*Eleusine indica*						o
Poaceae (Gramineae)		*Sporobolus spp.*						o
Polygonaceae	Coralita	*Antigonon leptopus*	Vine	Introduced	o		f	
Polygonaceae		*Coccoloba spp.*	Tree	Native	o		o	

Family	Common Name	Scientific Name	Growth habit	Provenance	Disturbed dry limestone woodland	Roadside scrub	Rural settlement and cultivation	Pasture and canefields
Polypodiaceae	Fern	*Asplenium sp.*	Fern	Native			o	
Polypodiaceae	Fern	*Nephrolepis sp.*	Fern	Undetermined				
Polypodiaceae	Fern	*Thelypteria dentate*	Fern	Introduced				
Polypodiaceae	Maidenhair Fern	*Adiantum spp.*	Fern	Native			o	
Punicaceae	Pomegranite	*Punica granatum*	Shrub	Introduced			o	
Rhamnaceae	Coolie Plum	*Ziziphus mauritiana*						
Rubiceae	Button Weed	*Borreria laevis*	Herb	Native			o	o
Rubiceae	Indigo Berry	*Randia aculeata var. aculeate*	Shrub	Native	o		o	o
Rubiceae	Ixora	*Ixora coccinea*					o	
Rubiceae	Noni	*Morinda citrifolia*	Herb	Introduced	o		o	
Rubiceae	Strongback	*Morinda rayoc*	Herb	Native	o		o	
Rubiceae		*Portlandia grandiflora*	Shrub	Endemic			o	
Rutaceae	Lime tree	*Citrus aurantifolia*					a	
Rutaceae	Orange tree	*Citrus sinensis*					a	
Rutaceae	Prickly Yellow	*Fagara martinicensis*	Tree	Native	o		o	
Sapindaceae	Ackee	*Blighia sapida*						
Sapindaceae	Guinep	*Melicoccus bijugatus*	Large tree	Introduced	o		f	
Sapindaceae	Wild Ackee	*Cupania glabra*	Large tree	Native			o	
Sapotaceae	Naseberry	*Manilkara sapota*	Large tree	Introduced			o	
Sapotaceae	Star Apple	*Chrysophyllum cainito*	Large tree	Native			a	
Sapotaceae	White Bullet	*Bumelia salicifolia*	Tree	Native		o	o	

Family	**Common Name**	**Scientific Name**	**Growth habit**	**Provenance**	**Disturbed dry limestone woodland**	**Roadside scrub**	**Rural settlement and cultivation**	**Pasture and canefields**
Scrophulariaceae	Russelia	*Russelia equisetiformis*	Herb	Introduced		o	o	
Simaroubaceae	Bitter Damson	*Simarouba glauca*	Large tree	Native		o	o	
Simaroubaceae	Macary Bitter, Majoe Bitter	*Picracmnia antidesma*	Shrub	Native				
Solanaceae	Devil's Trumpet	*Datura stramonium*	Herb	Native				
Solanaceae	Susumber	*Solanum torvum*			o	o	o	
Solanaceae	Tobacco	*Nicotiana tabacum*	Herb	Introduced			o	
Solanaceae	Wild Jasmine	*Cestrum diurnum*	Shrub	Native		o		
Sterculiaceae	Bastard Cedar	*Guazuma ulmifolia*	Small tree	Native		o	o	
Sterculiaceae	Cocoa	*Theobroma cacao*	Shrub	Introduced			o	
Sterculiaceae	Raichie	*Waltheria indica*	Herb	Native				
Theophrastaceae		*Jacquinea arborea*	Shrub	Native				
Turneraceae	Ram Goat Dashalong	*Turnera ulmifolia*	Herb	Native		o	o	o
Typhaceae	Bull Rush	*Typha domingensis*	Herb	Native				
Umbelliferae		*Hydrocotyle umbellate*	Herb	Native			o	
Verbenaceae	Clammy bur	*Priva lappulacea*					o	
Verbenaceae	Lantana	*Lantana reticulate*	Herb	Native			o	
Verbenaceae	Lantana	*Lantana camara*	Shrub	Native	o	o	o	o
Verbenaceae	Vervine	*Stachytarpheta jamaicansis*	Herb	Native	o	o	o	o
Vitaceae	Pudding With	*Cissus sicyoides*	Vine	Native				

Family	Common Name	Scientific Name	Growth habit	Provenance	Disturbed dry limestone woodland	Roadside scrub	Rural settlement and cultivation	Pasture and canefields
Vitaceae	Sorrel vine	*Cissus trifolia*	Vine				a	

Table 2: Bird survey points

NUMBER	NAME	HABITAT TYPE	DESCRIPTION	TIME	N	W	Elevation
1	MELROSE BY-PASS 2	Roadside scrub	Secondary scrub and pasture	640	18 24.0116	77 99.008	
2	MELROSE BY-PASS 2	Roadside scrub	Secondary scrub and pasture	655	18 03.007	77 26.479	882
3	MELROSE BY-PASS 3	Roadside scrub	Restored bauxite, scrub and pasture	704	18 02.300	77 22.836	652
4	PORUS 1	Rural settlement and cultivation	Food forest, pasture and houses	717	18 02.101	77 25.171	466
5	PORUS 2	Rural settlement and cultivation	Food forest, pasture and houses	729	18 01.805	77 24.927	451
6	PORUS 3	Rural settlement and cultivation	River corridor and fruit trees	742	18 01.608	77 24.048	430
7	SCOTTS PASS	Rural settlement and cultivation	Secondary scrub and pasture	805	18 00.882	77 22.807	495
8	CLARENDON PARK 1	Pasture and canefields	Canal, trees and pasture	827	17 59.365	77 21.685	193
9	CLARENDON PARK 2	Pasture and canefields	Pasture	839	17 58.924	77 29.632	198
10	SWEET AND JUICY	Pasture and canefields	Sugar Cane and pasture	855	17 58.003	77 18.405	178
11	CURATOE HILL	Disturbed dry limestone woodland	Secondary dry limestone woodland	919	17 56.821	77 15.144	265
12	MINERAL HEIGHTS	Disturbed dry limestone woodland	Secondary dry limestone woodland	936	17 56.157	77 13.859	295
13	SAVANNA CROSS	Disturbed dry limestone woodland	Secondary dry limestone woodland	956	17 58.174	77 12.386	188

Table 3: List of bird species observed and expected in study area

Status	Common Name	Scientific Name	Observed/expected in zone of influence	Observed in point counts	Habitat			
					Disturbed Dry Limestone Forest	Rural settlement and cultivation	Canefields and pastures	Roadside scrub
	Grebes	**Podicipedidae**						
b	Least Grebe	*Tachybaptus dominicus*	1				1	
b	Pied-billed Grebe	*Podilymbus podiceps*	1				1	
	Herons, Egrets & Bitterns	**Ardeidae**						
b	Great Egret	*Ardea alba*	1				1	
b	Little Blue Heron	*Egretta caerulea*	1				1	
b	Cattle Egret	*Bubulcus ibis*	1	1		1	1	
b	Green Heron	*Butorides virescens*	1				1	
	Ibises & Spoonbills	**Threskiornithidae**						
b	Glossy Ibis	*Plegadis falcinellus*	1				1	
	Ducks, Geese & Swans	**Anatidae**						
w	Blue-winged Teal	*Anas discors*	1				1	
	New World Vultures	**Cathartidae**						
b	Turkey Vulture	*Cathartes aura*	1	1	1	1	1	1
	Osprey	**Pandionidae**						
ws	Osprey	*Pandion haliaetus*	1				1	
	Hawks, Eagles & Kites	**Accipitridae**						
b	Red-tailed Hawk	*Buteo jamaicensis*	1		1			
	Falcons & Caracaras	**Falconidae**						
b	American Kestrel	*Falco sparverius*	1	1	1	1	1	1
	Plovers & Lapwings	**Charadriidae**						
b	Killdeer	*Charadrius vociferus*	1				1	

Status	Common Name	Scientific Name	Observed/expected in zone of influence	Observed in point counts	Habitat			
					Disturbed Dry Limestone Forest	Rural settlement and cultivation	Canefields and pastures	Roadside scrub
	Pigeons & Doves	**Columbidae**						
bi	Rock Dove	*Columba livia*	1	1		1		
b	White-crowned Pigeon	*Columba leucocephala*	1	1	1	1		1
b	Mourning Dove	*Zenaida macroura*	1		1			
b	Zenaida Dove	*Zenaida aurita*	1		1	1		1
b	White-winged Dove	*Zenaida asiatica*	1	1	1	1	1	1
bes	Common Ground-Dove	*Columbina passerina*	1	1	1	1	1	1
bes	Caribbean Dove	*Leptotila jamaicensis*	1	1	1	1		1
	Parrots, Macaws & Allies	**Psittacidae**						
bes	Olive-throated Parakeet	*Aratinga nana*	1	1	1	1	1	1
bi	Green-rumped Parrotlet	*Forpus passerinus*	1		1	1		
	Cuckoos	**Cuculidae**						
bes	Mangrove Cuckoo	*Coccyzus minor*	1		1	1		1
be	Jamaican Lizard-Cuckoo	*Saurothera vetula*	?			?		
be	Chestnut-bellied Cuckoo	*Hyetornis pluvialis*	?			?		
b	Smooth-billed Ani	*Crotophaga ani*	1	1	1	1	1	1
	Barn-Owls	**Tytonidae**						
b	Barn Owl	*Tyto alba*	1		1	1	1	1
	Typical Owls	**Strigidae**						
be	Jamaican Owl	*Pseudoscops grammicus*	1			1		
	Potoos	**Nyctibiidae**						
bes	Northern Potoo	*Nyctibius jamaicensis*	1		1	1	1	
	Nightjars & Allies	**Caprimulgidae**						

Status	**Common Name**	**Scientific Name**	**Observed/expected in zone of influence**	**Observed in point counts**	**Habitat**			
					Disturbed Dry Limestone Forest	**Rural settlement and cultivation**	**Canefields and pastures**	**Roadside scrub**
bs	Antillean Nighthawk	*Chordeiles gundlachii*	1		1	1		1
	Swifts	**Apodidae**						
b	White-collared Swift	*Streptoprocne zonaris*	1				1	1
b	Black Swift	*Cypseloides niger*						1
bce	Antillean Palm-Swift	*Tachornis phoenicobia*	1	1	1	1	1	1
	Hummingbirds	**Trochilidae**						
be	Jamaican Mango	*Anthracothorax mango*	1	1	1	1		
be	Red-billed Streamertail	*Trochilus polytmus*	1	1	1	1		1
bes	Vervain Hummingbird	*Mellisuga minima*	1	1	1	1		1
	Kingfishers	**Alcedinidae**						
w	Belted Kingfisher	*Ceryle alcyon*	1				1	
	Todies	**Todidae**						
be	Jamaican Tody	*Todus todus*	1		1	1		
	Woodpeckers & Allies	**Picidae**						
be	Jamaican Woodpecker	*Melanerpes radiolatus*	1	1	1	1	1	1
	Tyrant Flycatchers	**Tyrannidae**				1		
be	Sad Flycatcher	*Myiarchus barbirostris*	1		1	1		
bes	Stolid Flycatcher	*Myiarchus stolidus*	1		1			
bs	Gray Kingbird	*Tyrannus dominicensis*	1	1	1	1	1	1
bes	Loggerhead Kingbird	*Tyrannus caudifasciatus*	1	1	1	1	1	
	Swallows	**Hirundinidae**						
bs	Caribbean Martin	*Progne*	1				1	

Status	Common Name	Scientific Name	Observed/expected in zone of influence	Observed in point counts	Habitat			
					Disturbed Dry Limestone Forest	Rural settlement and cultivation	Canefields and pastures	Roadside scrub
		dominicensis						
b	Cave Swallow	*Petrochelidon fulva*	1	1	1	1	1	1
w	Barn Swallow	*Hirundo rustica*	1				1	
	Mockingbirds & Thrashers	**Mimidae**						
b	Northern Mockingbird	*Mimus polyglottos*	1	1	1	1	1	1
	Thrushes & Allies	**Turdidae**						
be	White-chinned Thrush	*Turdus aurantius*	1	1	1	1		
	Starlings	**Sturnidae**						
bi	European Starling	*Sturnus vulgaris*	1			1		
	Vireos & Allies	**Vireonidae**						
be	Jamaican Vireo	*Vireo modestus*	1	1	1	1	1	1
	New World Warblers	**Parulidae**						
w	Northern Parula	*Parula americana*	1			1		
w	Black-throated Blue Warbler	*Dendroica caerulescens*	1		1	1		
w	Prairie Warbler	*Dendroica discolor*	1		1			
w	Black-and-white Warbler	*Mniotilta varia*	1			1		
w	American Redstart	*Setophaga ruticilla*	1		1	1		1
w	Worm-eating Warbler	*Helmitheros vermivorus*	1			1		
w	Ovenbird	*Seiurus aurocapillus*	1			1		
w	Louisiana Waterthrush	*Seiurus motacilla*	1			1		
w	Common Yellowthroat	*Geothlypis trichas*	1					

Status	Common Name	Scientific Name	Observed/expected in zone of influence	Observed in point counts	Habitat			
					Disturbed Dry Limestone Forest	Rural settlement and cultivation	Canefields and pastures	Roadside scrub
	Bananaquit	**Coerebidae**						
bes	Bananaquit	*Coereba flaveola*	1	1	1	1		1
	Tanagers & Allies	**Thraupidae**						
be	Jamaican Spindalis	*Spindalis nigricephala*	1		1	1		
be	Jamaican Euphonia	*Euphonia jamaica*	1	1	1	1		1
	Buntings, Sparrows etc.	**Emberizidae**						
b	Yellow-faced Grassquit	*Tiaris olivacea*	1	1	1	1	1	
b	Black-faced Grassquit	*Tiaris bicolor*	1		1	1		
be	Orangequit	*Euneornis campestris*	1	1		1		
bes	Greater Antillean Bullfinch	*Loxigilla violacea*	1		1	1		
bi	Saffron Finch	*Sicalis flaveola*	1					
bes	Grasshopper Sparrow	*Ammodramus savannarum*	1				1	
	Troupials & Allies	**Icteridae**						
bes	Greater Antillean Grackle	*Quiscalus niger*	1	1			1	1
b	Shiny Cowbird	*Molothrus bonariensis*	1		1		1	
bes	Jamaican Oriole	*Icterus leucopteryx*	1		1	1		
		TOTAL	**69**	**27**	**41**	**47**	**33**	**25**
Classification based on H. Raffaelle "Birds of the West Indies."								
Status according to Downer and Sutton "Birds of Jamaica."								
Observed/expected in zone of influence based on previous observations and knowledge of habitat use and requirements								

Status	Common Name	Scientific Name	Observed/expected in zone of influence	Observed in point counts	Habitat			
					Disturbed Dry Limestone Forest	Rural settlement and cultivation	Canefields and pastures	Roadside scrub
Key b=breeding resident species be=jamaican endemic species bes=Jamaican endemic sub-species bs=summers and breeds m=non-breeding migrant								

Other List of Species

Common Name	Scientific Name
Cane Toads	*Bufo marinus*
Robber Frog	*Eleutherodactylus johnstoni,*
Laughing Frog	*Osteopilus brunneus*
Jamaican Snoring Frog	*Osteopilus crucialis*

APPENDIX V - ECONOMIC COST BENEFIT HIGHWAY 2000 PROJECT

In the context of an EIA of this scope, the prediction of economic impacts must remain conjectural. An economic justification for the H2K programme had been made using a traditional cost benefit analysis approach, which compared the flows of investment and operating costs over time with benefit flows *(Jamaica Development Bank – Dessau. Economic Cost Benefit Highway 2000 Project; Preliminary Design Phase. 2000)*. This study reported a significant IRR benefit of between 11.41% to 14.15% over the life of the project, although similar IRR calculations for both the Kingston to Mandeville and the Kingston to Montego Bay phases had somewhat lower values at 7.76% and 9.00% respectively. This study also described the main benefits of the highway: travel time savings; vehicle operation cost savings; and security-related savings (life, injuries, damage to property). The savings were -elated to the postponement of maintenance costs on other existing roads. Costs and benefits related to air quality were also noted; additionally, that study also recognized the different interest viewpoints of both the Concessionaire and the Government, with the focus of the latter being national benefits as derived from reduced national energy consumption. Additional benefits included improved labour productivity arising from passenger reduced travel time, and also social well-being, if reduced travel time resulted in increased leisure time.

The Consultants have no basis on which to question the continued validity of this major study. Neither are they able to do so, given the scope of this EIA. There are, however, legitimate flags that can be raised which suggest a certain timeliness in undertaking an economic review of the benefits of H2K 2000 sixteen years downstream. The reasons are twofold; firstly, the suggestions coming from the results of some international research about the economic relationship of highways to development; and secondly, the observations of the Consultants in relation to the impact of H2k on some local poorer communities.

International Research[7]. A case in point.

The World Road Association of the United Kingdom has a 100-nation membership. In 2015, it reported the findings of a review of more than 2,300 policy evaluations and evidence reviews from the UK and other OECD countries undertaken by the Research Councils UK, on the benefits of highway construction. It reported the following conclusions:

- Road projects can positively impact local employment, but effects are not always positive and a majority of evaluations show no (or mixed) effects on employment;
- Road projects may increase firm entry (either through new firms starting up, or existing firms relocating), however, this does not necessarily increase the overall number of businesses (since new arrivals may displace existing firms);

[7] *http://www.ciht.org.uk/en/wra/news/index.cfm/transport-can-have-a-positive-impact-on-the-local-economy*

- Road projects tend to have a positive effect on property prices, although effects depend on the distance to the project (and the effects can also vary over time);
- The impact of road projects on the size of the local population may vary depending on whether the project is urban, suburban or rural;
- There is some evidence that road projects have positive effects on wages or incomes;
- There is some evidence that road projects have a positive effect on productivity.

Nevertheless, the overriding conclusion was unambiguous. "*However, there are good reasons to invest in transport infrastructure beyond the impact on local growth".* This conclusion was made in relation to the correct mix of transportation modes, including air, rail, and sea, and their integrative role in the national and world economy.

The Consultants are unaware on any significant studies that have looked at the impact of H2k on near communities through which it passes. However, a search through local tertiary level archives has not been seriously pursued. The concern here is for small rural communities that can easily be marginalized in the pursuit of larger national economic goals. Studies have been done elsewhere and the findings of one such study, *"Economic Effects of Highway Relief Routes on Small- and Medium-Size Communities" by the University of Texas in Austin USA 2001,* though somewhat dated, raise the same issues observed (but not researched) by the Consultants. Reference to *highway relief routes* is what locally would be termed by-passes. Briefly enumerated, these issues are as follows:

- In most communities, businesses along the old route have declined significantly. A few communities have seen little change along the old route. A few others have seen considerable growth in retail businesses along the old route.
- Although the obvious explanation for the decline in businesses along the old route is the decline in traffic, other factors have also been important.
- Local gas stations, restaurants, and motels have all been affected by increased competition from national chains. Even towns without relief routes have seen a noticeable decline in locally owned businesses catering to through traffic.
- A few communities have seen little change in businesses along the old route, mostly because these businesses depended more on local customers than on through traffic.
- A handful of communities have seen considerable growth in retail businesses along the old route despite the opening of the relief route. In these cases, the community has remained important as a commercial centre for the surrounding region.
- Although many city leaders hope that a relief route will bring new development, the process is a slow one. In most communities, the amount of development along the relief route did not live up to local expectations.

- At the same time, a few communities have seen significant development along the relief route.

For a more balanced view, the study concludes that most of the changes in the above communities have been the result of factors other than the relief route, but that the relief route tends to amplify trends in the community, either positive or negative.

Larger communities located close to metropolitan areas or that serve as natural stopping points are in a better position to take advantage of the opportunities created by the relief route.

An important distinction between the by-passes studied and H2k developments is that the latter are tolled. This would reinforce the impacts felt by near communities.

The table below is extracted from this study reflects the following decline in business.

Table: Decline in Sales along Road Relief Routes in Small to Medium Communities in Texas, 2001

Small City of Pop 4,864.	Retail	Gasoline	Eat /Drink	Services
Per Capita Sales	–17.6%	– 47.6%	–3.7%	9.9%
No. of Establishments	–7.4%	–5.2%	–26.4%	–3.4%
Total Sales	–11.1%	–21.4%	–26.4%	–3.4%