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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

INTRODUCTION

An Environmental Impact Assessment (EIA) for the proposed construction of a bauxite reside disposal area (RDA 5) to be located adjacent existing RDAs at Halse Hall, Clarendon, was undertaken by Conrad Douglas & Associates Limited on behalf of Jamalco, the project proponent.

Essentially the proposed project is to facilitate additional residue disposal storage capacity since the present capacity can only accommodate approximately 18 months storage at the present production rate.

The proposed construction will utilise technologies that will significantly enhance the ability of the structure to withstand seepages or failure of the clay seal that is included in the design. In addition to the clay seal, the proposed disposal area will use a leachate collection system embedded in a layer of sand to collect and remove liquids before they can penetrate the clay seal.

The leachate system causes a zero hydrostatic head to be effected on the clay seal, thus minimizing the possibility of liner failure. Various approaches and methodologies were used in carrying out the study, consistent with and in addition to the requirements of the Terms of Reference, to ensure adequacy and completeness in addressing the potential impacts f the project.

These involved field and literature surveys including:

- Detailed reviews of the civil/structural components of the study,
- Alternative analyses of residue disposal methods considered by Alcoa and the bauxite/alumina industry in general,
- The environmental baseline setting, and
- Interviews and interactions with the members of the population within the sphere of influence of the study area.

TERMS OF REFERENCE

The Environmental Impact Assessment for the proposed construction of RDA 5 was conducted according the scope detailed a Terms of Reference (See Appendix I) which was approved by the National Environment and Planning Agency (NEPA).

REGULATORY FRAMEWORK

The policies, legislations and regulations as well as the permitting procedures and administrative framework relevant to the project were researched and analysed. The overriding legislation is the Natural resources Conservation Authority (NRCA) Act of 1991.

The objective was to ensure that the project complies with all policy, legal and regulatory requirements. The study therefore examined those policies, legislations and regulations governing environmental quality, health and safety, protection of sensitive areas, protection of endangered species, site selection and land use control.

ENVIRONMENTAL SETTING & BASELINE

In describing the environment of the proposed project, the specific location as well as the regional setting were studied and assessed.

The region was described in respect of its:

- biophysical resources
- socio-economics,
- cultural heritage resources, and
- future developments.

The topography of the region is predominantly flat and is characterised by low rainfall, low level biodiversity, possessing no identified rare or endemic species and no significant cultural heritage resources.

PROJECT DESCRIPTION

INTRODUCTION

Jamalco has received blanket approval from NEPA for its proposed upgrade to 2.8 Mtpy. However, Jamalco has been asked to provide additional information in support of specific aspects of the upgrade. This EIA report seeks to provide details and specific information in support of the establishment of a new Dry Bauxite Residue Disposal Area (RDA) that will be required to accommodate the residue from the upgraded refinery. Additionally, this EIA seeks the approval of NEPA so that the project can be implemented in a timely manner.

The construction of a new RDA represents a "Brown Site" expansion of the over 210 hectares (519 acres) of land designated to the sole purpose of residue disposal. RDA 5 will be located on approximately 100 hectares of land to the North of the existing RDA 4 and to the West of the existing RDA 2. It will provide additional storage volume and surface area to accept bauxite residue from the refinery. Using Thickened Tailings Disposal with Dry Residue Stacking technology, Jamalco will be able to maximize the capacity of RDA 5 and will be able to provide capacity for storage of 8.0 million cubic metres of residue.

The basic principles of Jamalco's residue plan are to firstly, maximize the storage of residue on the areas already used for this purpose (dike walls have been increased in height to increase volume), and secondly, to increase efficiency while utilizing the best available technology.

BASIS OF DESIGN

This project entails the preliminary engineering design and documentation of Dry Residue Disposal Area 5 covering approximately 100 Ha and associated works comprising of:

- Carrying out geotechnical investigations to determine the foundation conditions over the new RDA footprint.
- To identify possible sources of borrow material for the civil construction works.

- Base seal (to extend also within perimeter embankments and possibly under new embankment where adjoining RDAs are planned) likely to be a composite seal including a synthetic membrane and a clay layer.
- Under drain system on top of base seal likely to be made up of a sand layer with a grid of collection pipes for the purpose of collecting liquor as the residue above consolidates; also provision of recovery sumps.
- Surface decant system likely to be provision for mud deposition to profiles such that liquor separating from residue during deposition may be collected at a low point(s) from where it may be pumped to another location.
- Interior embankments or dikes (if required) to facilitate pipeline routes, drainage and deposition of residue to the required profiles.
- Storm drainage to accommodate run off from the mud surface recognizing that Jamalco is a zero discharge facility and that all run-off must be collected in existing sealed lakes.
- Perimeter embankments although likely to be of an initial lesser height to be designed such that they may be later raised to an elevation matching those of the surrounding RDAs, constructed of compacted locally excavated borrow material. Top of dyke to be suitable for two way traffic.
- Access ramps in the south west corner to service the Under Drain Sump and in the north east corner to replace the existing ramp included within RDA 5.
- Provision of an embankment for a future Residue Neutralisation Plant or additional Paste Thickener with the same plan area at RL 195' as the existing thickener embankment.
- Provision of a 90,000 m^3 final capacity Oxalate Storage Area in the north east corner of RDA 5.
- Installation of dust suppression sprinkler system
- Area roads, including a service road around the perimeter of the new West and North dykes, and vehicle access ramps to embankment crests; likely to be of simple crushed limestone construction with side drains.
- Foundations and support trestle for lake water recovery station(s).
- Foundations for any tanks or mechanical equipment.
- Miscellaneous small buildings – possibly an electrical substation and several offices.

- Early warning system monitoring well system for leakage through the sealing membrane.
- Protection of the dyke from flooding

DESIGN CRITERIA

The design criteria to be used for the preliminary design of RDA 5 is summarised below.

- Storage of 8 million cubic metres of bauxite residue dry stacked at 3% sloping up from the new west perimeter dyke to a maximum level of 190 feet.
- Provision of approximately 100Ha of surface drying area of bauxite residue at the 190' RL residue level.
- Storage of storm water runoff from RDA 5 only, for the 1 in 100 year rainfall event.

Table 1-1, provides key quantities and capacities of the proposed RDA 5.

The project will provide jobs for a variety of workers since the labour force at the peak of construction is expected to be approximately 250 workers (operators, foremen, general labour) with supervisory staff at 25.

THE RDA SYSTEM

RDA 5 is proposed for lands adjoining the existing RDA 4 (to the south) and RDA 2 (to the east). Figure 1-1 depicts the location plan of the proposed residue disposal area and Figure 1-2 shows the details of the general plan layout. Construction activities are anticipated to last for an estimated 14 months from start of construction.

The major components of the RDA 5 include:

- A Seal Layer
- An Under-DrainSystem
- Embankments

The above components represent the integral components of RDA 5, and have been designed to promote and effect the safe and efficient physical storage and processing of bauxite residue.

Other components of RDA 5 include:

- A lakewater return system
- An oxalate Storage Cell
- Stormwater Storage
- Stromwater Drainage

PROJECT DESCRIPTION

1 PROJECT DESCRIPTION

1.1 GENERAL DESCRIPTION OF PROJECT

1.2 INTRODUCTION

Jamalco has received blanket approval from NEPA for its proposed upgrade to 2.8 Mtpy. However, Jamalco has been asked to provide additional information in support of specific aspects of the upgrade. This EIA report seeks to provide details and specific information in support of the establishment of a new Dry Bauxite Residue Disposal Area (RDA) that will be required to accommodate the residue from the upgraded refinery. Additionally, this EIA seeks the approval of NEPA so that the project can be implemented in a timely manner.

The construction of a new RDA represents a “Brown Site” expansion of the over 210 hectares (519 acres) of land designated to the sole purpose of residue disposal. RDA 5 will be located on approximately 100 hectares of land to the North of the existing RDA 4 and to the West of the existing RDA 2. It will provide additional storage volume and surface area to accept bauxite residue from the refinery. Using Thickened Tailings Disposal with Dry Residue Stacking technology, Jamalco will be able to maximize the capacity of RDA 5 and will be able to provide capacity for storage of 8.0 million cubic metres of residue.

The basic principles of Jamalco’s residue plan are to firstly, maximize the storage of residue on the areas already used for this purpose (dike walls have been increased in height to increase volume), and secondly, to increase efficiency while utilizing the best available technology.

1.3 BACKGROUND

Jamalco produces 1.1 tons of residue for every ton of alumina produced and presently has four active residue disposal areas (RDAs) covering 214 hectares. RDA 1 was commissioned in 1972, RDA 2 in 1980, RDA 3 in 1990, and RDA 4 in 1997. RDAs 1 and 2 are simple clay lined impoundments. The construction of RDAs 3 and 4 included an under−drainage system to improve the rate of consolidation of the residue and to reduce the hydrostatic pressure on the clay seal at the base of the deposits. RDA 1 is now being used as a cooling water pond, and a project is being commissioned in October 2005 to convert 20 hectares of its area to a Thickened Tailings Disposal Area. RDA 2 has been filled with wet residue and is currently being used for the Paste Thickener overflow and lake water storage. The embankments of RDAs 3 & 4 were raised in 2003. The resulting expanded area RDA 3/4 is an active RDA into which all residue produced by the refinery is being discharged as thickened tailings.

Jamalco is a zero discharge facility, in that all water collected from the plant site or the residue system is impounded within the disposal area for reuse in the process. In addition to residue disposal, RDAs 1,2 and 3/4 are currently used to store accumulated rainfall runoff during the year.

Allowing for the current production rate (1.27 Mtpa) and sufficient capacity to store rainfall run off collected in a wet year (equivalent to 1979), it is anticipated that RDA 3/4 will reach capacity by November 2006. At that time additional residue storage capacity will be required. Needless to say, the refinery cannot operate without proper residue disposal solutions.

The area currently set aside for future expansion is bounded by RDAs 1&2 to the east, RDA 4 to the south, the Rio Minho River to the west and Webber's Gully to the north. It is intended that RDA 5 be constructed in this area.

1.3.1 BASIS OF DESIGN

This project entails the preliminary engineering design and documentation of Dry Residue Disposal Area 5 covering approximately 100 Ha and associated works comprising of:

- Carrying out geotechnical investigations to determine the foundation conditions over the new RDA footprint.
- To identify possible sources of borrow material for the civil construction works.
- Base seal (to extend also within perimeter embankments and possibly under new embankment where adjoining RDAs are planned) likely to be a composite seal including a synthetic membrane and a clay layer.
- Under drain system on top of base seal likely to be made up of a sand layer with a grid of collection pipes for the purpose of collecting liquor as the residue above consolidates; also provision of recovery sumps.
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- Foundations and support trestle for lake water recovery station(s).

- Foundations for any tanks or mechanical equipment.
- Miscellaneous small buildings – possibly an electrical substation and several offices.
- Early warning system monitoring well system for leakage through the sealing membrane.
- Protection of the dyke from flooding

1.3.2 DESIGN CRITERIA

The design criteria to be used for the preliminary design of RDA 5 is summarised below.

- Storage of 8 million cubic metres of bauxite residue dry stacked at 3% sloping up from the new west perimeter dyke to a maximum level of 190 feet.
- Provision of approximately 100Ha of surface drying area of bauxite residue at the 190' RL residue level.
- Storage of storm water runoff from RDA 5 only, for the 1 in 100 year rainfall event.

Table 1-1, provides key quantities and capacities of the proposed RDA 5.

TABLE 1-1: KEY QUANTITIES AND CAPACITIES OF THE PROPOSED RDA 5

Item	Quantity
In service:	
Tailings Storage Volume	8,200,000 cu m
Water Storage Volume	560,000 cu m
Oxalate Storage Volume	50,000 cu m
Surface Area (when full)	99 Hectares
Construction:	
Sand (under drain layer)	620,000 cu m
Clay (seal layer)	460,000 cu m
General fill	1,340,000 cu m
Total fill quantities:	**2,420,000 cu m**

The project will provide jobs for a variety of workers since the labour force at the peak of construction is expected to be approximately 250 workers (operators, foremen, general labour) with supervisory staff at 25.

1.4 THE RDA SYSTEM

RDA 5 is proposed for lands adjoining the existing RDA 4 (to the south) and RDA 2 (to the east). Figure 1-1 depicts the location plan of the proposed residue disposal area and Figure 1-2 shows the details of the general plan layout. Construction activities are anticipated to last for an estimated 14 months from start of construction.

FIGURE 1-1: MAP OF THE PROPOSED SITE

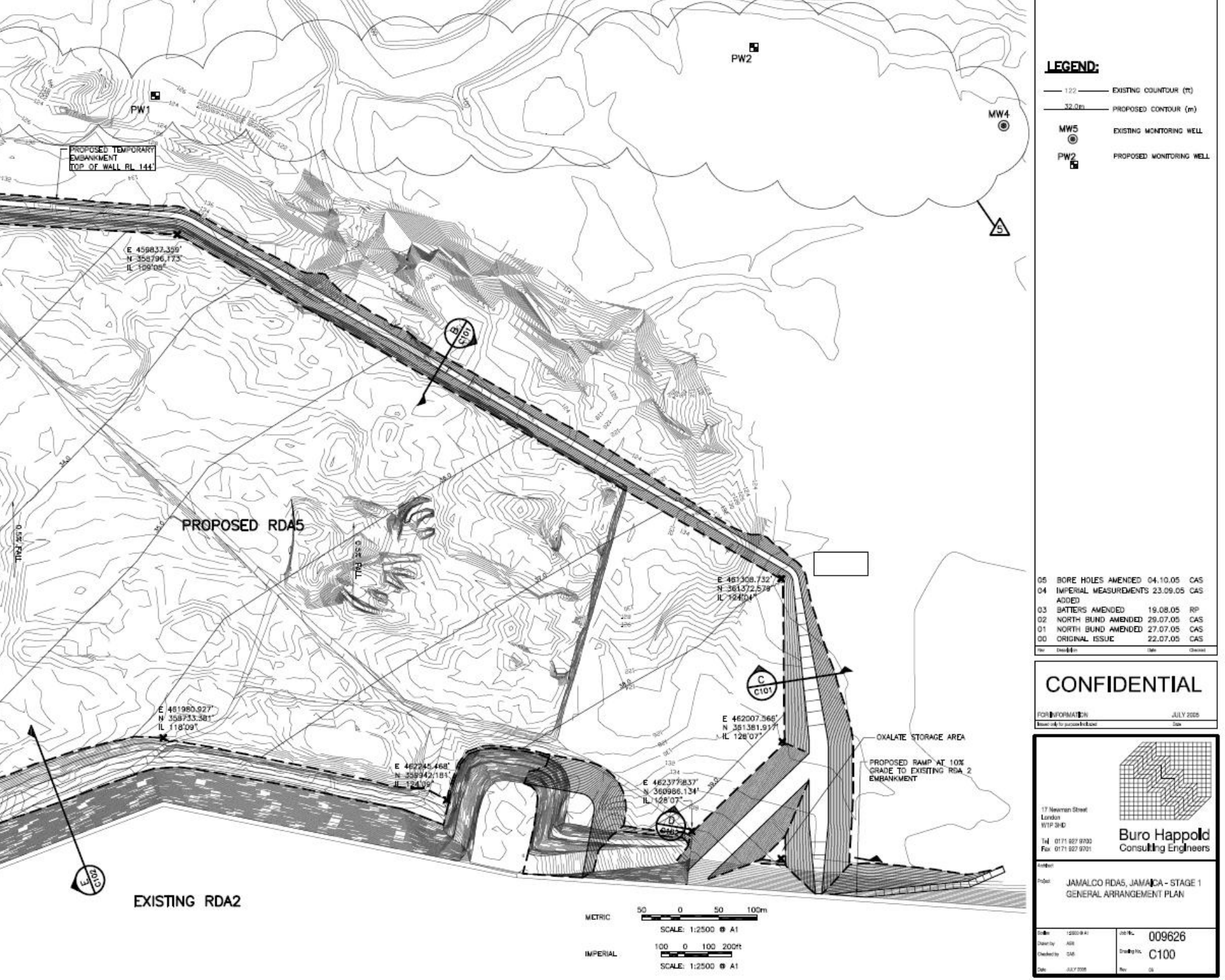


FIGURE 1-2: RDA 5 GENERAL PLAN LAYOUT DETAIL

1.4.1 MAJOR COMPONENTS

1.4.1.1 SEAL LAYER

The preservation of the valuable groundwater resources of the Vere Plains is of significant importance to Jamalco. For this reason, they pioneered the use of sealed residue disposal impoundments in Jamaica. The concept is relatively straightforward and involves the use of an impermeable liner between the residue and natural ground. In the past, thick clay liners have been used which were made from select clays and compacted for maximum protection against failure. To date, Jamalco has not experienced any significant liner failures at the residue disposal area and through extensive preliminary works, safety oriented designs and high quality construction works, will continue to do so with the construction of RDA 5.

RDA 5 will be constructed with a composite liner system comprising an 18" thick compacted clay liner with a 0.75mm thick PVC geomembrane on top of the clay. The geomembrane's mechanical protection on the internal slopes will be provided by compacted layers of soil. On the base, a 2'6" thick sand layer will be placed on top of the geomembrane.

The PVC geomembrane liner will further increase the impermeability of the liner system and act as a first line of defence in the protection of the clay liner. This system of liners coupled with a proven under-drain system will provide a factor of safety greater than in any other RDA unit constructed at Jamalco to date.

To maintain the integrity of the combined liner system, the works will be sequenced so that the clay is not left exposed to drying or wetting conditions and that the PVC be covered by the sand drainage blanket to protect it from the elements and construction activities, as soon as practically possible. Installing the drainage system progressively with the drainage blanket will reduce the impact on the liner of vehicle passes over the completed surface.

The geomembrane will be covered early in the construction process for the following reasons:

- To provide protection from puncturing by mechanical means.
- To provide protection from the environment, including protection from UV light.
- To prevent rucking, caused by downslope creep, being “locked-in” by deposition of residue.
- To avoid long term drying out and possible shrinkage cracking of the underlying clay liner.

A cover of fill will provide the required protection for geomembrane on the internal slopes of RDA 5 with the following details applied:

- The fill placed immediately over the geomembrane will not contain particles coarse and sharp enough to puncture PVC; as such 300 mm or finer material will be used for this purpose.
- The cover should be thick enough to be placed by conventional earthmoving and compaction equipment over the existing outside slopes of RDA 2 and RDA 4 (after removal of topsoil).
- The cover should not be so thin that it would become saturated during heavy rainfall events and slough-off, as infiltration will not be able to pass through the PVC liner.

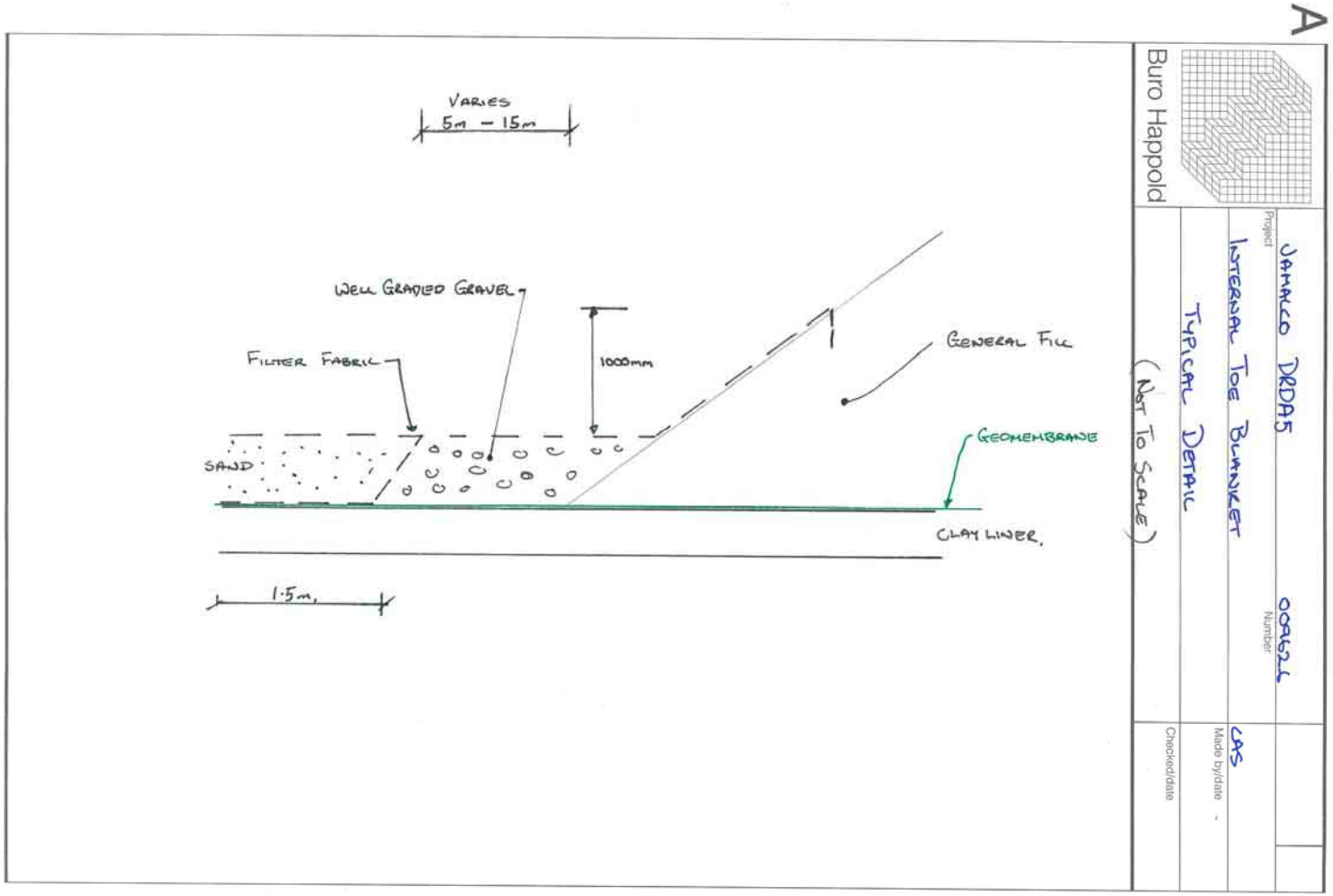


FIGURE 1-3: INTERNAL TOE EMBANKMENT

1.4.1.2 UNDER-DRAIN SYSTEM

The preliminary design for the under drainage system has been based on perforated, dual wall and ribbed polyethylene pipes with a tubular, seamless filter sock. The proposed pipes are N12 pipes as supplied by Advanced Drainage Systems.

The under drainage layout and pipe design was based on an assumed tailings permeability of 10-7 metres per second, and the pipes sized using the Colebrook White Equation for pipes flowing full. The under floor drainage network is a simple herringbone system with a primary collection main, secondary mains at generally 150m centres and 100mm lateral mains generally at 50m centres. The collection main drains to a reinforced concrete under floor drainage sump that has been located in the Western Embankment towards the south west.

A section through the composite liner would show the compacted clay layer overlain with the PVC geomembrane. Over the PVC liner, there would be a shallow sand layer to protect the liner with the pipes bedded on this sand. Protecting the pipes and providing the required haunch support and filtration of fines is a further sand layer. The overall sand thickness is currently proposed to be approximately 750mm.

The selection of the suitable pipes was based on the ultimate perimeter embankment height of 195 feet and a design tailings slope of 5% rising from the 190 foot level on the western embankment to the middle of RDA5 and then falling at 5% back to the 190foot level on the Western RDA 2 embankment. This provided an ultimate design overburden pressure equivalent to approximately 50m. Single wall, flexible pipes were considered, however they are unlikely to be satisfactory due to their inability to withstand the ultimate, proposed overburden pressures that will be exerted.

To accommodate for the possible need for draining the embankment slopes, drainage pipes have been allowed around the inside toe in lieu of extending the herringbone system up the embankment slope.

FIGURE 1-4: PROPOSED DRAINAGE LAYOUT – RDA 5

For the sand drainage layer, a permeability of at least 1*10 -5 m/sec is required to limit water pressure between laterals at 50 metre intervals. To achieve this target permeability of 1*10 -4 m/sec for sand from the borrow area will be applied to allow for variation, unless processing of the sand is provided. A geofilter fabric has been allowed as a separator between the sand drainage layer and the tailings.

The under floor drainage sump is currently proposed to be a 5m diameter, cast insitu concrete structure. It is proposed to be located within the outer slope of the western embankment. The foundations and structure have been designed based on the assumption that it will be eventually raised to the 195foot level with a short access bridge from the crest to the top of the sump.

1.4.1.3 EMBANKMENTS

The embankments of RDA 5 will be similar to those presently used at the other 4 RDAs. In this case, the clay and geomembrane liners extend beneath the embankment, which will be constructed of general fill materials compacted to desired specifications. The porous filter fabric will extend up the embankment. (See Figure 1-3).

1.4.1.3.1 EMBANKMENT PROFILE AND MODEL GEOMETRY

The overall embankment shape will vary along its length to suit the existing topographical conditions.

The schematic cross-section of the dyke that was modeled as part of the stability analyses is geometrically similar to those used in the previous studies. The generalized design profile comprises:

- A 12.5 m high (41.0 ft) compacted earthfill bund with upstream/downstream batter side slopes both at 1V:2H and a 8m wide crest (26.25 ft) at an elevation of +44.0 m above mean seal level (approx.144.00 ft amsl). Granular and cohesive engineering fills will be used to form the earthworks materials.
- A 1.25 m thick (4.10 ft) liner cover system on the upstream side, consisting of a 0.75m thick (2.46 ft) granular layer overlying a 0.50m thick (1.64 ft) compacted clay layer. This external cover system also extends over the entire RDA floor.

In terms of the underlying design ground model, a horizontal stratum interface was introduced at 5.0 m (16.4 ft) beneath the embankment. In addition, no internal or basal drainage control measures were incorporated into the design model as it is assumed that the compacted clay layer on the upstream slope is impermeable and will not leak.

1.4.2 CONCEPT DESIGN AND ANALYSIS

1.4.2.1 DESIGN METHOD AND CRITERIA

The Stage 1 embankment design was undertaken in accordance with the Minimum Factor of Safety failure criteria summarized in Table 1-2. These adopted minimum required factors of safety against slope instability are based on Alcoa's "Bauxite Residue Management Standards & Guidelines" (2004) and generally accepted US/UK geotechnical engineering practice.

TABLE 1-2: SUMMARY OF ADOPTED SLOPE STABILITY DESIGN CRITERIA

Design Loading Case	Seismic/Dynamic Condition	Minimum Factor of Safety	
		Downstream Slope	***Upstream Slope***
Short Term (ie. end of construction)	Static	1.5	1.5
Long Term (ie. operational, full reservoir, design freeboard)	Static	1.3	1.3
Earthquake	Pseudo-static	1.0	1.0

The analyses were performed using the SLOPE/W computer program (version 6.14) developed by GEO-SLOPE International Ltd, Canada which employs the two-dimensional limit equilibrium method of slices. The minimum factors of safety for the most critical circular slip surface were computed by the Morgenstern-Price (M-P) method that satisfies both moment and force equilibrium static conditions. A half-sine force function was also defined for characterising the normal and shear interslice forces used by the M-P method.

In general, the M-P method tends to produce slightly less conservative results compared with the different analysis methods used by others during the previous stability studies (namely, Bishops modified and Janbu methods).

For assessment of the seismic stability, the horizontal and vertical inertial forces created by earthquake ground shaking were defined as:

F = aW/g = kW

where

a = pseudostatic accelerations

g = gravitational acceleration constant

W = weight of failure mass or interslice

k = seismic coefficient of acceleration

The dynamic loading conditions applied was a horizontal inertial force (Fh_h) acting upstream and positive vertical inertial force (Fv_v) acting downwards in the direction of gravity, to reduce the embankment's mass and stability. In addition, the vertical seismic coefficient (kv_v) was taken as 50% of the horizontal seismic coefficient (kh_h).

1.4.2.2 MATERIAL DESIGN PARAMETERS

Due to the unavailability of site-specific geotechnical data for the proposed embankment and its underlying ground conditions, an upper and lower bound set of material parameters were generally used in the stability analyses, as summarised in Table 1-3. The effective stress (shear strength) parameters adopted for the granular and cohesive soils were both unfactored.

TABLE 1-3: SUMMARY OF ADOPTED SLOPE STABILITY DESIGN SOIL PARAMETERS FOR PROPOSED RDA5

Soil Model	Material Type	Material Property (Lower & Upper Bound)		
		Bulk Unit Weight, γ (kN/m3)	***Effective Cohesion, c' (kN/m2)***	***Effective Angle of Friction, ϕ' (°)***
EMBANKMENT FILL	Cohesive (upstream zone only)	20.0	10 & 5	26 & 30
	Granular	18.0	2.5 & 0.0	34 & 40
EMBANKMENT COVER LAYER (UPSTREAM)	Cohesive	20.0	5	28
	Granular	18.0	0	30
FOUNDATION	Cohesive	20.0	15 & 5	26 & 30
	Granular	18.0	2.5 & 0.0	34 & 40
	Bedrock (impenetrable layer)	N/A	N/A	N/A

1.4.2.3 DESIGN GROUNDWATER CONDITIONS

A design piezometric surface at approximately 23 m (75 ft) depth was generally used in the analyses to represent the regional ground water table in the underlying limestone aquifer.

Furthermore, a typical range of pore water pressure coefficients (Ru values) from 0.0 to 0.2 were applied to determine the sensitivity of pore water pressures changes being generated:

- Within the saturated upstream cohesive embankment fill due to construction processes or reservoir water impoundment variations;
- Within the near surface downstream granular embankment fill as a result of extreme seasonal precipitation effects.

1.4.2.4 DESIGN SEISMIC CONDITIONS

Horizontal pseudostatic accelerations ranging from between 0.0g and 0.25g were also adopted in the dynamic stability analyses to model potential earthquake ground shaking effects (ie. horizontal seismic coefficient kh_h = 0.0 to 0.25).

The design methodology/approach and range of values used are similar to those employed in the previous “non-complex” seismic studies undertaken.

1.4.2.5 CONCLUSION

For the design long term and seismic conditions modelled, the proposed RDA5 perimeter embankment has satisfactory factors of safety.

1.4.2.6 RESIDUE DEPOSITION

All mud slurry will be routed through the existing Paste Thickener, dewatered to between 31-34% solids and pumped to RDA 5 by means of the existing centrifugal underflow mud slurry pumps.

Residue will be deposited from the existing RDA 2 West embankment i.e. from the East side of the proposed RDA 5 and will naturally slope from East to West. There will also be a facility to discharge from the North (part only) and South edges of the proposed RDA 5. There will be no central discharge points.

The work shall include the fabrication and installation of approximately 4,000'-0" of 16" diameter piping from the discharge flange of the existing Paste Thickener mud slurry pumps and along the circumference of RDA 5. A new 16" line will be installed along the West and North (part only) embankments of RDA 5. The existing line along the North of RDA 4 will be utilised by turning alternate mud droppers to discharge into RDA 5. In addition, the work shall further include the fabrication and installation of approximately forty (40) mud droppers along the circumference of RDA 5.

The advantages of thickened tailings disposal coupled with dry stacking, is that it offers

- a stable mass during the life of the facility
- a higher storage density per unit area than wet disposal
- high shear strength
- high bearing capacity

The high bearing capacity offered by this technology is of importance during the rehabilitation and closure of a storage area as it facilitates early rehabilitation after closure, allows access to the disposal area for pipe installation or modification during the operating life of the area.

This technology will make possible the storage of an additional 19 million tonnes of residue in RDAs 2, 3 and 4 over and above the wet storage capacity, and 14 million tonnes of residue in a 100 hectare facility such as RDA 5. This will be accomplished without having to construct larger dikes for RDA 5.

1.4.3 OTHER COMPONENTS

1.4.3.1 LAKEWATER RETURN SYSTEM

The RDA 5 Lakewater Return System will be similar to the existing system in RDA 3 / 4. Pumps will be located on a pontoon to be located in the SW corner of RDA 5, and lakewater pumped to RDA 2.

1.4.3.2 OXALATE STORAGE CELL

An Oxalate Storage Cell is required within RDA 5. The Oxalate Storage Cell is to be in the NE corner of RDA 5, and to be of a similar general arrangement as the existing Oxalate Cells in the corners of RDA 3 and RDA 4.

The Oxalate Storage Cell is to provide 90,000 m^3 final storage capacity. The Stage I Oxalate Storage Capacity is 50,000m^3 (i.e. prior to raising the embankment to design final level +195 ft.) The splitter embankment will be raised and the North embankment locally raised, as appropriate, to achieve this Stage I capacity. The concept design considers a wide base to the splitter embankment reducing at constant side slope of 1.75H : 1V to the design final crest level.

1.4.3.3 STORMWATER STORAGE

RDA 5 is designed to accommodate surface run-off from rainfall falling on RDA 5 only and the design case is 100% run-off from a single 1 in 100 year rainfall event. It is intended that immediately after this rainfall event, storm water would be transferred by pumping rapidly to RDA 2. The sizing of this pumping system is part of the detailed mechanical design, it is proposed for the pumping system to be designed to allow removal of this storm water to RDA 2 within 3-5 days. The run-off storage capacity of RDA 5 will become critical only towards the end of its Stage I life. It may make sense to upgrade the pumping system only at this time, or to raise the perimeter embankments before this time.

It is often preferable for water to run off by gravity to a local storm pond, and to be pumped away from there. There is no provision for this in the design of RDA 5. It is accepted that part of RDA 5 will remain flooded for a short time as water is pumped off. Jamalco's present strategy is to have sufficient storm water surge capacity available to contain all rainfall events and with zero discharge.

Jamalco’s plan is to dredge 2.0 million m3 from RDA 2 and dewater to this dredged level, to provide further storm water surge capacity. Milestones will be to create an additional 1.0 million m3 water storage capacity by the end of November 2006, and the full amount of 2.0 million m3 by the end of 2007.

Implicit in this strategy for RDA 5 is maintaining a minimum pool level before rain and to have sufficient pumping capacity to raise excessive stormwater runoff up into RDA 2.

1.4.3.4 STORMWATER DRAINAGE

Rip rap and gravel in wire wrapped mattresses will be required to avoid erosion due to stormwater runoff at select locations on both the inside and outside embankment slopes.

Stormwater run-off from the embankments will run over the protective cover to the liner and collect at the base of the slopes. Particularly on the existing RDA 2 and RDA 4 slopes, there is considerable catchment and during heavy rainfall events, there is the potential for the exposed sand drainage blanket to be washed away by the accumulation of rainfall runoff flowing along the toe towards the south west corner sump. Rip rap with a width of 15m with a depth of rip rap of 0.75m will be placed over the sand layer and geofilter fabric along the toes of the internal slopes.

On the outside slopes of the new perimeter embankments, there will be surface channels at select locations allowing controlled stormwater discharge downslope from the crest. The external earth embankments will be hydro-seeded, with maintenance watering carried out to establish adequate vegetation cover.

1.4.4 EXTENSION TO PASTE THICKENER EMBANKMENT

The existing Thickener Embankment Platform will be extended, as part of the RDA 5 project. This is for the purpose of possible future installation of a second Paste Thickener and/or Residue Neutralisation Facility. The extension of the existing Embankment is required on the north side of the existing platform, and will result in a doubling of the existing level platform at RL 195 ft.

The earthworks would involve taking the existing "rectangle" of level platform at approximately RL 195 ft, adjoining the RDA 2 West Embankment, and constructing an embankment extension that would give another "rectangle" of the same level platform area adjoining the existing platform and the RDA 1 W embankment.

The existing Access Ramp is constructed to the same specification as the existing embankment, and may be retained as part of the Embankment Extension. The part of the access ramp not in the new works will be removed as a source of material and to increase tailings storage. A new Access Ramp in the north east corner of RDA 5 will be required.

1.4.4.1 CONSTRUCTION PHASES

As with all major construction projects, this project will be implemented in phases. Activities proposed for RDA 5 encompass the following 3 basic phases:

1. Pre-construction
2. Construction, and
3. Operational phases

1.4.4.1.1 PRE-CONSTRUCTION PHASE

Pre-construction will involve the following activities:

a) Demolition and removal of interferences other than earthen structures enclosed within the exterior toe lines of the new dikes. The area proposed for location of RDA 5 is relatively bare and has no major interferences.
b) Removal of any boulders that may be in the area and cannot be used in the project.
c) Clearing and grubbing of all vegetation such as brush roots, stumps and bushes within the specified project area, including clay and sand borrow areas.
d) Stripping of approximately 4 to 18 inches of top soil which will be stockpiled and stored for landscaping and revegetation of the external dike walls.

1.4.4.1.2 CONSTRUCTION PHASE:

Construction activities will involve the following:

a) Excavation and stockpile of materials (area has good quality clay deposits).
b) Loading, hauling and unloading of excavated material for use in the construction of the ramp for the dike areas and for the actual dike construction. The areas

where this material will be used include the sloped dike clay seal, the bottom areas to be clay sealed and intermediate stockpiling areas within the interior dike toe lines for later use in dike and bottom construction.

c) Excavation of sand and clay from borrow areas located in proximity to the proposed RDA. Approximately 620,000 m^3 of sand and 460,000 m^3 of clay will be required to complete the RDA.
d) Spreading and compaction of materials in the bottom of the lake and dike areas. Spreading of materials will be uniform to ensure that a homogenous thickness is achieved. The materials will be compacted and brought to suitable moisture content levels which will be achieved through aeration and spraying. These activities are necessary to facilitate proper compaction levels.
e) Installation of drainage piping network.
f) The outer slopes will be stabilised after compaction with the placement of top soil and hydroseeding. Slopes will be maintained at 2:1, so that proper drainage will occur protecting slopes from erosion caused by water run-off.

The sand and clay borrow areas will be graded, capped with topsoil and allowed to undergo natural re-colonisation.

1.4.4.1.3 OPERATIONAL PHASE:

During this phase, residue slurry from the plant will be pumped to the paste thickener from which the paste will be pumped to the stacking areas, allowed to drop onto the existing stack where it will lose additional moisture and stabilise in the RDA. Collected leachate will flow to a collection sump from where it will be pumped into a storage area.

Regular observation, maintenance and verification of the integrity of the RDA will be conducted, the same as is done for the other 4 RDAs at the Jamalco facility.

1.5 SOURCES OF CONSTRUCTION BORROW MATERIAL

1.5.1.1 GENERAL

Suitability of the borrow materials will be assessed from the ground investigation results during the detailed design. Materials compliance testing will be ongoing during construction, and a suitably qualified geotechnical engineer will be on staff to undertake inspections during the earthworks.

Ground water is not generally present in the clay borrow area. However, a water management strategy will be put in place for stormwater runoff and collection in the clay borrow pit. Groundwater is expected, dependant on the flow in the river, in the sand borrow area located in the flood plain. Temporary stockpiling of sand may be required, should it be feasible to place the sand drainage blanket during periods of high river flow.

1.5.1.2 RESERVOIR FLOOR

To level the reservoir floor about 550,000 cubic metres (720,000 cubic Yards) of material will be excavated. Most of this will be suitable for Type B fill material and can either be used to fill the lower areas of the reservoir floor or in embankments.

1.5.1.3 CLAY BORROW AREA

The electrical resistivity survey to the north of the proposed RDA5 footprint revealed the presence of a clay unit that could provide suitable material for the RDA5 basal and side clay liner. Ten boreholes were constructed with a Dando cable-percussive rig to a maximum depth of 15.5m BGL (51ft BGL) to verify the presence of the clay and to provide samples for confirmatory laboratory testing. About 800,000 cubic metres (1,050,000 cu. yds) of clay have been located in this area. Overburden above the clay would be suitable for Type B fill. The quantity of this overburden is about 250,000 cubic metres (330,000 cu. yds).

1.5.1.4 SAND BORROW AREA

An area of sand in the flood plain of the Rio Minho, which was previously exploited during the construction of RDA's 3 and 4, was investigated as a potential source of material for the drainage blanket at the base of RDA5. Fifty machine excavated trial pits were dug to identify the nature of the material and the likely quantities available. This work was carried out in a number of phases, to locate sand with a low fines content which tended to be present closer to the Rio Minho.

1.5.1.5 GENERAL FILL BORROW AREA

There is a shortfall of about 900,000 cubic metres (1.200,000 cu. yds) of general fill (Type B) required for the proposed construction after excavation for the RDA 5 floor. Material which is not suitable for Type C drainage sand from the area investigated for sand would be suitable for Type B. Another area north west of RDA5 (adjacent to the clay borrow area described in Section 6.3) was investigated with 13 machine dug trial pits and large quantities of silt/clay were found which would be suitable for Type B. At least 800,000 cubic metres (1,050,000.yds) have been found in this area.

Together with the 250,000 cubic metres (330,000 cubic yards) of overburden in the clay borrow area and material unsuitable for Type C in the sand borrow area, enough Type B material is available. The general fill borrow area could be extended, subject to geotechnical investigation, if a shortfall in Type B material is expected towards the end of construction.

1.6 EQUIPMENT LIST

Jamalco RDA 5 Project **Rev 2**
Plant & Equipment List **Revised 31-Aug-05**
COMBINED LOCAL & OVERSEAS HIRE

TABLE 1-4: PLANT AND EQUIPMENT LIST

Item	Model (or similar alternative)	Rating	No. to be mobilised
Imported Earthworks			
Dump Truck	Cat D400E ADT	36.5te 22.0 m3 6x6 ADT	**24**
Dozer	Cat D6R LGP	123kw, 18te	**2**
Dozer	Cat D6R Regular	123kw, 18te	**1**
Dozer	Cat D7 or similar	To push out soil tipped by ADTs	**3**
Water Bowser	Cat D400E ADT	36.5te 22.0 m3 6x6 ADT	**4**
Grader	Cat 16H	205kw, 27.3te, 4.88m blade	**2**
Soil Dozer / Compactor	Cat 815F SP padfoot	164kw	**2**
4WD Tractor + plough	Case MX270	300HP	**2**
Tyre Service Truck	with Hi-ab crane boom	6x4 Dropside truck , 12.6te	**1**
Fuel Bowser	Bedford 6x4 16m3		**1**
Excavator	Cat 365BME	287Kw / 385 HP, 2.3-3.5m3	**3**
Excavator	Cat 345		**1**
Service Truck		16te GVW 4x4	**1**
13t SP Vibratory Roller	Smooth Drum	Smooth Drum	**3**
19t SP Vibratory Roller	Bomag BW219 SP	Smooth Drum with padfoot shells	**3**
Subtotal			**53**
Local Hire Earthworks			
Motorscraper	Cat 631E	365 kw 21 / 31 yd3	**8**
Dozer	Cat D9R	302kw, 48te	**2**
Dozer	Cat D8	212kw, 37te	**1**
Dozer	Cat D6R LGP	123kw, 18te	**1**

Item	Model (or similar alternative)	Rating	No. to be mobilised
Dozer	Cat D6R Regular	123kw, 18te	**1**
Grader	Cat 16H	205kw, 27.3te, 4.88m blade	**2**
Excavator	Cat 330	166 kw, 34t, 1.1-2.1m3	**2**
Tipper (general)		6x4 16.5m3 / 25te	**9**
Tipper (earthworks)		6x4 16.5m3 / 25te	**8**
Water Bowser		6x4 16m3	**2**
13t SP Vibratory Roller	Smooth Drum	Smooth Drum	**1**
Subtotal			**37**

1.7 CIVIL AND GEOTECHNICAL ENGINEERING

Extensive civil and geotechnical assessments were conducted in support of this project. A wide cross-section of professionals, technologies and techniques were brought together to generate data and information to verify the capacity of the selected area to house the RDA and to insure that if constructed to the appropriate factors of safety, it would be unlikely that the RDA would experience a major failure.

As well as boreholes and test pits, a geophysical investigation method was employed incorporating Resistivity imaging using a CAMPUS Tigre 64 system. This was used to map the depth to the Limestone Subcrop and to characterize the materials in this zone.

Resistivity imaging methods were used to perform this task. The survey consisted of 6 (no.) profiles orientated north-south over the survey area, with 12 (no.) traverses orientated east-west. These were spaced at approximately 150 m centres. Analysis of the results produced a cross-section along each resistivity line, which highlighted the vertical and lateral changes in the subsurface layering. Depth to the Limestone Subcrop was highlighted in the sections as a continuous layer at depth, and this was transferred into a contour map over the survey areas.

Resistivity data was collected and found to be of good quality with similar values being observed across all the survey areas. The geological interpretation of the resistivity surveys is based on the four categories of subsurface materials identified (three categories of Alluvium and one of Limestone). Generally the near surface resistivity values display values that have been attributed to the Rio Minho alluvium identified in the boreholes. Lower than average values are associated with clay-rich or saturated deposits and high values with dry deposits or gravels.

The majority of the surveys also displayed a sharp increase in resistivity at depth, which through correlations with boreholes has been identified as underlying weathered limestone of the Newport Formation.

The geological interpretations presented have been based on correlation with borehole data, which together with the extensive nature of the site dictates that the ground model presented in the drawings is general.

The results of the geotechnical field investigations to date (geophysical and borehole) indicate that the area is suitable for the installation and operation of the intended RDA. Given that the site is underlain by Newport Formation Limestone that is reported to be karstic and to contain cavities elsewhere in Jamaica, a micro-gravity study has been scheduled to confirm/deny the possibility of there being large sinkholes under the site sufficiently close to the surface to present potential stability problems to the RDA.

Review of currently available GI information on sinkholes leads us to the conclusion that an approach to consider them as part of the construction works is required. It is emphasised that risk from a sinkhole cannot be completely removed; an approach to reduce risk to a level acceptable to Jamalco is summarised below:

1. Microgravity survey the whole plan area of RDA 5 to look for large (say > 10 m across sinkholes). Review results and proof drill (rotary percussive rock drill) as necessary.
2. Microgravity survey of the site area where the limestone is close to the proposed floor level (say within 5 m depth) to look for smaller sinkholes up to about 5 m across. Review results and proof drill as necessary to identify areas suitable for dynamic compaction.
3. Options to consider for remediation of a large sinkhole include drilling and filling the hole with a low mobility grout, and where feasible not constructing the RDA over the sinkhole.
4. Identified areas of shallow, smaller sinkholes where the limestone is closer to the floor should be treated with dynamic consolidation.
5. Reinforcement of the underside of the liner with geogrid. The extent is not easy to quantify at this stage and further work will be required once the size and nature of any sinkhole identified is better understood.

1.7.1 EARTHWORKS

Various compaction tests are ongoing to demonstrate that Standard Proctor may be used as a reference for all materials. Some modifications to the earthworks specification used for RDA 3 & 4 are anticipated, with some of the changes resulting from proposed trials described below. For continuity, the categorisation of materials used for the raising of RDA's 3 and 4 will be adopted for RDA 5, which was:

Type A – Impervious fill with k < 10 x 10-9 m/s (0.1 ft/yr). These soils can be defined under the Unified Soils Classification System (USCS) as CH, CL, MH or ML materials. In other words it has more than 50% passing No.200 sieve.

Type B – General fill needs to have sufficient shear strength to form the embankments and where used to regulate the reservoir base it must be relatively incompressible. Our current understanding is that most of the material found within RDA 5 above the formation level will be suitable (other than those which can be used as Types A & C).

Type C – Drainage material. This will have a relatively low coefficient of uniformity. It will be fine gravel and sand, hopefully with less than 5% fines.

Excavation methods will be selected to mix the excavated material vertically and in so doing minimise the requirement for any subsequent blending, sorting or mixing.

It is intended to provide a statistically based requirement for compaction in the specification for earthworks. This will allow a percentage of results below the required average and (similar to concrete testing) will require the plotting of moving averages. Action will be needed if the results show sudden changes or an adverse trend. This method allows much more flexibility in assessing compaction test results than a fixed cut-off value.

The aims of the compaction trial for each material category are:

- Type A - to determine the compactive effort to achieve 95% Standard Proctor Maximum Dry Density (SMDD) at Standard Optimum Moisture (SOMC) to SOMC + 2.5%, and that the resulting material has a permeability less than 10 x10-9 m/s (0.1 ft/yr).
- to demonstrate that the Material Type B can be compacted using reasonable compactive effort to 100 % SMDD at SOMC +or - 1.5%. Field permeability tests will be undertaken to assess the permeability of Type B materials.
- to confirm that Material Type C has adequate permeability for a drainage blanket when compacted in field conditions. The compaction target is 70% relative dry density. (ASTM D4254)

- to calibrate the nuclear densimeter and hand penetrometer with the materials to be used.

The testing done has demonstrated that relatively light equipment is adequate to achieve the required compaction. During the construction works further trials may be used to demonstrate that heavier plant working on thicker layers can achieve the same density with greater cost efficiency. It is also intended to demonstrate in the compaction trials that materials can be adequately moisture conditioned in the works. At this stage it is estimated that between 5 and 8% moisture will have to be added.

1.8 DUST SUPPRESSION SYSTEM

1.8.1 GENERAL

A Dust Suppression System will be installed suitable to provide adequate sprinkler dust suppression over the entire plan area of the proposed RDA 5.

The work shall include the installation of one (1) new Water Production Well and one (1) new submersible pump at a location to be determined. The work will also include the fabrication and installation of approximately 7500' of 16" Dia. pipe at RDA 5 along a path of its circumference. The work will also include the fabrication and installation of a grid of 12" dia., 10" dia., 8" dia., and 6" diameter piping at various locations along RDA 5. In addition, the work will further involve the installation of approximately 300 Nelson Big Gun Type F100T sprinkler heads at strategic points over the plan area of RDA 5. This work shall serve as the basis of water supply for new dust suppression system at RDA 5.

1.8.2 MECHANICAL

One (1) 20" NPS standard weight casing will be installed to a depth of approximately 230' below the earth surface. One (1) submersible pump will be installed for water supply. Perimeter fencing will be installed for protection of the new submersible well pump station.

1.8.3 PIPING

A16" diameter header, approximately 7500' of fabricated 16" diameter piping from the new well location along RDA 5 will be installed and 12", 10", 8" and 6" diameter piping along with approximately 300 Nelson Big Gun type F100T (Full) sprinkler heads, will also be fabricated and installed.

1.8.4 STRUCTURAL

A concrete foundation and supports for the new submersible pump will be fabricated and installed. Various pipe supports and guides as per specifications set out in drawings will be fabricated and installed.

1.8.5 DUST MONITORING STATIONS

Two new Dust Monitoring Stations will be supplied and installed at locations to be determined on the perimeter embankments of RDA 5

1.9 MONITORING WELLS

A series of wells will be installed to allow monitoring of the groundwater quality, as follows:

- Two new monitoring wells (Ref PWI and PW2) to supplement the existing wells (Ref MW4 and MW5) will be located between RDA 5 and the Rio Minho to meet NEPA monitoring requirements.
- Up to eight new monitoring wells, positioned along the proposed toe of the new perimeter embankments, are also proposed. These would extend to a depth of about 120 feet to intercept the upper levels of the limestone aquifer, where any contamination due to leakage would first be encountered. Testing of recovered groundwater samples will be to NEPA requirements.

1.10 CLOSURE AND REHABILITATION STANDARDS

Jamalco is currently undertaking developmental work to streamline its rehabilitation plan. The current plan involves the minimization of operations in the selected disposal areas targeted for rehabilitation. This will allow the surface to be kept almost free of additional moisture while allowing for normal evaporative processes to take place.

The plan primarily involves three basic activities:

- Dewatering,
- capping and
- grading re-vegetation

1.10.1 DEWATERING

Dewatering is required to lower the phreatic line in the residue to facilitate draining and to allow an increase in shear strength and bearing capacity of the residue. These activities are necessary for subsequent capping.

The dewatering programme will be initiated after the last bauxite residue is deposited in the area, the extent of which will depend on existing or future water levels in the residue disposal area.

At the outset, the liquor level in the area will be lowered to allow rainfall and liquor generated from consolidation to flow out of the area. In addition pumping and other passive dewatering methods will be used to convey accumulated liquor off the lake. By achieving an increased and acceptable level of the solid content at the surface of the residue more *extensive* dewatering methods will be applied.

It is proposed to construct a ditch around the perimeter (inner) of the area to be decommissioned. This will be initiated once the residue has developed sufficient strength to support a ditch without failing. Periodic deepening of the perimeter ditches is critical to the dewatering activities since the residue surface needs to develop the strength to support the ditch geometry.

The deepening of the ditch is dependent on the rate of desiccation which will be accelerated by the use of standard and proven techniques. Once the dewatering activities are sufficiently achieved and the load bearing capacity is developed, capping of the facilities will be initiated.

1.10.2 CAPPING/GRADING AND RE-VEGETATION

Capping the residue with suitable material signals the second phase of the closure operations. Potential capping materials will constitute reject low grade bauxite materials and adjacent native overburden soils; these will be used to accomplish the following main objectives:

- provide a surcharge stress that will cause additional consolidation of the residue,
- reduce or eliminate potential dust emissions,
- provide a growing medium for the re-vegetation phase,

The capping material will be systematically pushed onto the desiccated, dewatered residue surface. The capping activities will sequentially and progressively proceed towards the centre of the residue area from the embankment; this will allow areas that are mud waved to be left unworked to undergo further desiccation.

Initially a thin layer of capping material will be placed on the residue surface and will be followed by further addition of material to achieve a given target thickness and reclaimed topography.

Once the required thickness and topographic characteristics capable of conveying run-off from the reclaimed-lake are in place, the area will be ready for re-vegetation. Materials capable of preventing wind and soil erosion are proposed for the re-vegetation of the rehabilitated areas.

It should be noted that it may be necessary to install a residue stabilization system to assist the dewatering activities and potential problems due to dust emissions.

1.10.3 JAMALCO RESIDUE MANAGEMENT PLAN

Jamalco has initiated a red mud disposal and management plan spanning the period 1995 to 2020 (25 years). This plan will essentially form the base-line against which future disposal of red mud will be assessed and evaluated, in addition, detail plans and strategies for the closure and rehabilitation of the residue disposal facilities are addressed.

A constant production rate of 849,000 tonnes of alumina per annum and a residue to alumina factor of 1.08 tonne/tonne forms the basis of the residue management plan. It is proposed that at the end of the planning period a total of 34 million tonnes of residue will be stored in five residue deposits covering approximately 400 hectares of land (including the existing RDAs). The fundamental principles captured by the residue disposal plan intend to achieve two major objectives, these being:

- to maximise the storage of residue in areas already allocated for this purpose.
- to utilize the best available technology for residue management. This technology should minimise negative environmental impacts, co-exist and comply with tightening governmental regulations while meeting community expectations and Alcoa's residue standards.

The objectives itemised above formed the basis for the analysis of alternatives considered by Jamaica.

1.11 NATURAL HERITAGE RESOURCES

The Company's activities take a particular interest in preserving existing and potential historical sites within the project area. The operations are guided by and must comply with the Jamaica National Heritage Trust and Alcoa's World Alumina strict Environment, Health and Safety Standards. In addition to any resource already identified, every effort will be made to further identify, locate and document anything that can be considered significant from a cultural or natural heritage perspective. Pre-construction through the operational phases of the project will be managed to avoid or handle appropriately (through direction from the Jamaica National Heritage Trust all such features that may be encountered.

Policy, Legislation and Regulations

2 POLICY, LEGISLATION AND REGULATIONS

2.1 POLICY, LEGAL & ADMINISTRATIVE FRAMEWORK

This section provides a background on Alcoa's (Jamalco) Environmental Policy and International & National Policies, Legislation and Regulations applicable to the proposed expansion of the Jamalco facility (Residue Disposal Areas).

2.1.1 ALCOA'S POLICIES, PRINCIPLES AND GUIDELINES

2.1.1.1 ALCOA'S ENVIRONMENTAL POLICY

The Jamalco facility, under the management of Alcoa, strives to meet or exceed all environmental policies and regulations locally and within its corporate structure. As such, the facility is operated under strict guidance and guidelines to insure compliance at all levels of operation. The following information is derived from the existing Jamalco Environmental Policy Document.

It is Alcoa's policy to operate world-wide in a manner which protects the environment and the health of our employees and of the citizens of the communities where we have an impact.

- ✓ We will comply with all applicable environmental laws, regulations and permits, and will employ more restrictive internal standards where necessary to conform with the above policy.
- ✓ We will anticipate environmental issues and take appropriate actions which may precede laws or regulations.
- ✓ We will work with government and others at all levels to develop responsible and effective environmental laws, regulations and standards.
- ✓ All Alcoans are expected to understand, promote and assist in the implementation of this policy.

2.1.1.2 ALCOA'S ENVIRONMENTAL PRINCIPLES

In support of Alcoa's Environmental Policy, the following principles have been developed to provide additional direction on specific issues. The implementation plan, which follows, provides details on how the Policy and Principles will be carried out.

- ✓ *We will support Sustainable Development*
- ✓ Alcoa will incorporate sustainable development into our operations by integrating environmental considerations into all relevant business decisions. We will achieve cleaner production through programs of waste minimization and pollution prevention with specific and measurable reduction targets.
- ✓ *We will practice responsible use of natural resources*
- ✓ Alcoa will utilize the best available information to plan and execute all projects that involve extraction of raw materials, or which may restrict the use of natural resources or impact ecosystems.
- ✓ *We will utilize techniques accepted as best practices on a worldwide basis for resource extraction, resource use, waste management, and rehabilitation of ecosystems disturbed by our activities.*
- ✓ *We will use energy wisely*
- ✓ Alcoa will strive to maximize efficient energy use, conserving non-renewable resources.
- ✓ *We will practice sound environmental management*
- ✓ Alcoa will integrate environmental management fully with business and operating management to ensure that long-term and short-term environmental issues are considered together with market and economic aspects when decisions are made about new and existing facilities, processes, products, services, acquisitions and divestitures.
- ✓ *We will provide training and information*

- ✓ Alcoa will sponsor training in the environmental area. We will also provide employees, suppliers, customers and neighbours with information needed to understand and help us achieve the goals of our environmental policy.

- ✓ *We will audit our operations and report findings*

- ✓ Alcoa will audit each of its operations on a regular basis to identify strengths and weaknesses of the location's environmental management process and to identify actions that need to be taken to prevent environmental problems or correct environmental deficiencies. Appropriate management, including the Alcoa Board of Directors, will be informed of the audit findings.

- ✓ *We will sponsor activities to improve the science of environmental protection.*

- ✓ Alcoa will sponsor and conduct research and development (including application of emerging technologies) to improve our ability to predict, assess, measure, reduce, and manage environmental impacts of our operations. We are committed to continuous improvement in all aspects of our environmental performance.

- ✓ *We will develop and adhere to high standards.*

- ✓ Alcoa will develop and implement worldwide environmental standards and best practices with emphasis on areas that are unique to our business.

- ✓ *We will report on our activities*

- ✓ Alcoa will communicate promptly and openly with individuals and communities regarding the environmental aspects and impacts of our operations, as well as with concerned parties who request such information. Alcoa will also provide an annual Environmental Health and Safety report that describes our programs, plans and performance. The report will be made available to shareholders and the public.

2.2 LOCAL POLICIES, LEGISLATION AND REGULATIONS

2.2.1 POLICY, LEGISLATION, REGULATIONS & STANDARDS

The following represents descriptions of applicable legislative requirements with which activities of this proposed upgrade must comply:

- Agenda 21
- Natural Resources Conservation Authority (NRCA) Act, 1991
- Wildlife Protection Act, 1945
- Watershed Protection Act, 1963
- Town & Country Planning Act, 1987
- Forestry Act, 1937
- Water Resources Act/Underground Water Control Act, 1959
- Jamaica National Heritage Trust Act, 1985
- Public Health Act, 1985
- Disaster Preparedness & Emergency Management Act, 1993
- National Solid Waste Management Authority Act, 2001
- Occupational Safety & Health Act, 2003 (DRAFT)
- Clarendon Parish Provisional Development Order, 1982

2.2.1.1 AGENDA 21

In June 1992, Jamaica participated in the United Nations Conference for Environment and Development (UNCED) in Rio de Janeiro, Brazil. One of the main outputs of the conference was a plan of global action, titled Agenda 21, which is a “comprehensive blueprint for the global actions to affect the transition to sustainable development”

(Maurice Strong). Jamaica is a signatory to this convention. Twenty seven (27) environmental principles were outlined in the Agenda 21 document. Those relevant to this project, which Jamaica is obligated to follow are outlined below:

The United Nations hosted the EARTH SUMMIT '92 and from this conference twenty - seven (27) environmental principles were outlined. Not all of these principles are applicable to the project but those deemed relevant and appropriate are outlined below.

2.2.1.2 NATURAL RESOURCES CONSERVATION AUTHORITY ACT, 1991

The Act is the overriding legislation governing environmental management in the country. It also designates National Parks, Marine Parks, Protected Areas and regulates the control of pollution as well as the way land is used in protected areas.

This Act requires among other things, that all new projects or expansion of existing projects which fall within a prescribed description or category must be subjected to an Environmental Impact Assessment (EIA).

The regulations require that eight (8) copies of the EIA Study Report must be submitted to the Authority for review. There is a preliminary review period of ten days to determine whether additional information is needed. After the initial review the process can take up to ninety days for approval. If on review and evaluation of the EIA the required criteria are met, a permit is granted.

Specifically, the relevant section(s) under the Act which addresses the proposed mining activities are:

s.10: (1) Subject to the provisions of this section, the Authority may by notice in writing require an applicant for a permit of the person responsible for undertaking in a prescribed area, any enterprise, construction or development of a prescribed description or category-

(a) to furnish the Authority such documents or information as the Authority thinks fit; or

(b) where it is of the opinion that activities of such enterprise, construction or development are having or are likely to

have an adverse effect on the environment, to submit to the Authority in respect of the enterprise, construction or development, an EIA containing such information as may be prescribed, and the applicant or, as the case may be, the person responsible shall comply with the requirement.

s.12: Licenses for the discharge of effluents etc.

s.17: Information on pollution control facility

s.18: Enforcement of Controls – threat to public health or natural resources

s.32-33: Ministerial Orders to protect the environment

s.38: Regulations

2.2.1.3 WILDLIFE PROTECTION ACT, 1945

This act involves the declaration of game sanctuaries and reserves, game wardens, control of fishing in rivers, protection of specified rare or endemic species. The Act also provides for the protection of animals and makes it an offence to harm or kill a species which is protected. It stipulates that, having in one's possession "whole or any part of a protected animal living or dead is illegal.

This Act has to be considered for the proposed project, ecological assessments will determine if rare or endangered species will be impacted.

2.2.1.4 WATERSHED PROTECTION ACT, 1963

This Act governs the activities operating within the island's watersheds, as well as, protects these areas. The watersheds which are designated under this Act include Rio Minho, Cane River and Rio Nuevo watersheds areas.

Determinations will be made to identify any potential impacts that this project may have on the various watershed areas and will propose mitigative actions where impacts are identified.

2.2.1.5 TOWN & COUNTRY PLANNING ACT, 1987

This Act governs the development and use of land. Under this law the Town Planning Department is the agency responsible for the review of any plans involving industrial development. The law allows for specific conditions to be stipulated and imposed on any approved plans. This planning decision is based upon several factors, these include;

- the location of the development
- the nature of the industrial process to be carried out
- the land use and zoning
- the effect of the proposal on amenities, traffic, etc.

This Act is applicable to the proposed plant and port upgrades and mining activities.

2.2.1.6 3.2.1.6 FORESTRY ACT, 1937

This Act provides for the management and the declaration of Forest Reserves on Crown Lands and regulates activities in Forest Reserves. This Act will be reviewed to determine if the upgrade activities (particularly mining) will impact on Forest Reserves and to what extent.

2.2.1.7 3.2.1.7 WATER RESOURCES ACT; THE UNDERGROUND WATER CONTROL ACT, 1959

The Underground Water Control Act of 1959 is the legal instrument and is enforced by the Water Resources Authority (WRA). The Water Resources Act is expected to provide for the management, protection, controlled allocation and use of water resources of Jamaica. Thus the water quality control for both surface and ground water are regulated by this Act.

If the proposed facility intends to utilize any existing ground water, permission would be needed, in the form of an issued license for this activity. Under this Act exploratory activities such as the boring/drilling of wells for the purpose of searching for underground water without the written consent would be a violation.

In addition, any activity which negatively influences the quality of existing water, whether ground or surface, would be relevant to this Act.

The proposed project will impact on:

- Ground water resources as it proposes, to increase ground water extraction rates.

2.2.1.8 3.2.1.8 JAMAICA NATIONAL HERITAGE TRUST ACT, 1985

The Act is administered by the Jamaica National Heritage Trust, formerly the Jamaica National Trust. This Act provides for the protection of important areas, including the numerous monuments, forts, statues, buildings of historic and architectural importance in Jamaica.

In the approved mining area (SEPL 530), several historic sites and buildings have been identified within the general area of this project; these include several churches, schools, Great Houses and natural features of significant importance to our heritage.

During this project, an Archaeological and Heritage Retrieval Plan will be implemented to protect any historical or archaeologically significant item encountered.

2.2.1.9 3.2.1.9 THE PUBLIC HEALTH ACT (1974)

This Act controls and monitors pollution from point sources. Any breaches of this Act would be sent through the Central Health Committee which takes action through the Ministry of Health, Environmental Control Division (E.C.D.). The ECD has no direct legislative jurisdiction, but works through the Public Heath Act to monitor and control pollution from point sources. Action against any breaches of this Act would be administered by the Central Health Committee. The functions of the department include:

- The monitoring of waste water quality, including regular water quality analysis, using water standards published by NEPA;
- Monitoring of occupational health as it relates to industrial hygiene of potentially hazardous working environments;
- Monitoring of air pollutants through its laboratory facilities.

In addition, there are various sections of this legislative instrument which governs and protects the health of the public. Relevant sections under the Public Health Act of 1985, are Sections 7.- (1) *A Local Board may from time to time, and shall if directed by the Minister to do so, make regulations relating to (o) nuisances* and 14.- (1) *The Minister may make regulations generally for carrying out the provisions and purposes of this Act, and in particular, subject to section 7, but without prejudice to the generality of the foregoing, may make regulations in relation to (d) air, soil and water pollution.*

Aspects of the project related to odour have been considered since odour is a part of the Air Emissions regulations to be promulgated in 2004.

2.2.1.103.2.1.10 DISASTER PREPAREDNESS AND EMERGENCY MANAGEMENT ACT, 1993

The principal objective of the Act is to advance disaster preparedness and emergency management measures in Jamaica by facilitating and coordinating the development and implementation of integrated disaster management systems. Jamalco has established procedures and guidance documents in place in terms of disaster preparedness and emergency management.

2.2.1.113.2.1.11 NATIONAL SOLID WASTE MANAGEMENT AUTHORITY ACT, 2001

The National Solid Waste Management Authority (NSWMA) under this Act has the responsibility to manage and regulate the solid waste sector. It includes requirements for licences for operators and owners of solid waste disposal facilities (in addition to permit requirements of NEPA).

2.2.1.123.2.1.12 OCCUPATIONAL SAFETY & HEALTH ACT, 2003 (DRAFT)

This Act oversees the prevention of injury and illness resulting from conditions at the workplace, the protection of the safety and health of workers and the promotion of safe and healthy workplaces.

Sampling of sections from the Draft Act that are relevant to this project, include:

4. (1) This Act applies to all branches of economic activity and to all owners, employers and workers in all such branches.

5. (1) The owner of every industrial establishment or mine which carries on business on or after the appointed day shall, subject to subsection (8), apply to the Director in the prescribed form to be registered under this Act.

18. (1) Provides a description of the duties of employers, outlining the need for quality work areas and work environments, procedures and guidelines that will result in safe and healthy workplaces.

19. (1) discusses the duties of employers at construction sites in terms of employee safety and health during work activities.

25. (1) an employer shall make or cause to be made and shall maintain an inventory of all hazardous chemicals and hazardous physical agents that are present in the workplace.

26. (1) this section provides guidelines and procedures for employers to follow in terms of identification of hazardous chemicals. This includes labeling and identification protocols.

30. (1) Basically, this section of the Act requires an employer to provide training of its employees with a potential for exposure to hazardous chemicals or physical agents.

It is expected that this Draft Act will be Gazetted in the near future. As such, it is important that Jamalco have an understanding and appreciation for its contents.

2.2.1.13 Clarendon Parish Provisional Development Order, 1982

This document provides the development plan for the Parish of Clarendon. It clarifies the role and responsibility of the local planning authority and provides guidance on how development of the parish should proceed. All activities in this proposed upgrade of the Jamalco operations that requires local planning authority approval will be properly identified and the appropriate permits and licenses will be secured.

Special note: The Jamaica Bauxite Institute (JBI) is the regulatory agency monitoring the bauxite industry, and as such their policies will extend to any development on bauxite owned lands.

2.2.2 SUMMARY OF THE LEGISLATION AND RESPONSIBLE AGENCIES

TABLE 3-1: NATIONAL LEGISLATION AND RESPONSIBLE AGENCIES

LEGISLATION	INSTITUTION RESPONSIBLE
NRCA Act, 1991	Natural Resources Conservation Authority
Wildlife Protection Act, 1945	Natural Resources Conservation Authority
Watershed Protection Act, 1963	Natural Resources Conservation
Town & Country Planning Act, 1987	Town Planning Department
Forestry Act, 1937	Forestry Department
The Water Resources Act/UWC Act, 1959	Water Resources Authority
Ja. National Heritage Trust Act, 1985	Jamaica National Heritage Trust
Public Health Act, 1985	Ministry of Health/Environmental Control Division
Disaster Preparation & Emergency Management Act, 1993	Office of Disaster Preparedness and Emergency Management
National Solid Waste Management Authority Act, 2001	National Solid Waste Management Authority
Clarendon Parish Provisional Development Order, 1982	Town Planning Department

DESCRIPTION OF THE ENVIRONMENT

3 DESCRIPTION OF THE ENVIRONMENT

Information for this section has been compiled from field observations and ground truthing to verify the accuracy of information sourced from reports including:

1. EIA for Step-in-Dyke RDA#1 (CD&A – 2005),
2. EIA for 2.8 Million Metric Tonne Per Year Efficiency Upgrade at JAMALCO – (CD&A -2004),
3. Biosurvey of Jamalco's Special Mining Lease Area in Southern Manchester – (BEG's LTD. – 2000),
4. Floral and Faunal Survey of Jamalco Special Mining Lease Areas and Environs of the Refinery and Port Facilities (BEG's LTD. - 2005), and
5. Report on Webbers Gully Floodplain Mapping for Alcoa Train Line – Rio Minho River – (2005).

3.1 LAND USE AND GEOLOGY

3.1.1 LAND USE

Jamalco's current RDAs are sited on lands formally occupied by sugarcane cultivation which were divested by Monymusk Sugar Factory.

The Bowens community which previously occupied lands located on the western side of RDA 1 and 2 was relocated to what is now called New Bowens. The relocation was to facilitate expansion of Jamalco's residue disposal storage capacity.

RDA 5 will be constructed on approximately 100Ha of lands owned by Jamalco and lies adjacent to the other RDAs (East and South perimeters will be bounded by the existing RDA 2 and RDA 4 embankments).

Two residential communities are located within one half mile of the RDA's, New Bowens to the Northeast and Cornpiece to the Southeast.

3.1.1.1 HISTORICAL

3.1.1.1.1 CLARENDON

3.1.1.1.1.1 Topography

The topography of Clarendon is characterised by the diverse nature of the coastal fringe and offshore islands and cays. The national and marine park and protected area of the Brazilletto Mountains, Portland Ridge, Peake Bay, Portland Bight and the plains in the Southern areas with elevations from 0-150 meters, the Mocho Mountains at elevations of 150-300 meters, extending to the limestone uplands in the north around main ridges, and the Bull Head Mountain.

3.1.1.1.1.2 Area and Land Cover

Clarendon contains an area of 1142.8 km^2.

Land cover in Clarendon is characterised by a scattering of villages and major urban centres, vast areas of sugar cane, wetlands, dry forests, scrub, industrial estates, aquaculture, mixed cultivation including bananas, citrus, subsistence crops by small farmers which includes yams, peas, sweet potatoes, etc.; the decline of the sugar industry has left large areas abandoned and taken over by scrub vegetation. Uncultivated areas due to salinity include much of the coastal side of the plains. Tidal flats are largely inaccessible. There are also the dry forests of the Brazilletto Mountains and the Portland Ridge, where Taino petroglyphs and some Taino burial caves are to be found.

3.1.1.1.1.3 Industrial Development Plan

Light industrial land use is confined to the rural/urban settlements and linear occupancy along district, sub-arterial and arterial roads. Heavy and special industrial plants include bauxite processing plant at Halse Hall (Jamalco), sugarcane processing at Moneymusk and New Yarmouth.

Transportation and access routes including all classes of roads and railway lines link all urban centres and also penetrate agricultural areas, national parks and conservation areas.

TABLE 3-1: URBAN SETTLEMENT DEVELOPMENT

CLARENDON – HEIRARCY OF GROWTH CENTRES		
District Centres	**Sub-Regional Centres**	**Regional Centres**
James Hill	Lionel Town	May Pen
Kellits		
Hayes		
Chapelton		
Kemps Hill		
Osbourne Store		
Mocho		
Rock River		
Chapelton		
Frankfield		
Alston		

3.1.1.1.1.4 Parish Council/Land Use Zoning

The parish of Clarendon is covered by Development Orders and subsequently falls under the aegis of the Town and Country Planning Act. Thus any form of development requires an application to the relevant Local Planning Authority (Parish Council) for permission to carry out building, engineering and mining operations or change in the use of land or buildings.

There are no specific demarcated zones for land use, but there are general statements of intended uses, supporting requirements and standards. This project does not present a change in land use for the site specified.

3.1.1.1.1.5 Aesthetics

There are several areas of outstanding natural beauty, visual and recreational amenity, and therapy. There are also areas which are felt to be aesthetically appealing and spiritually inspiring. The view from the Brazilletto Mountains over the protected Peake Bay and West Harbour wetlands and the sea is outstanding. The Milk River Bath is world renown for its therapeutic quality, and the Canoe Valley-Portland Bight wetlands supports considerable marine life and is itself outstandingly beautiful.

A wide variety of micro climates exits in the parish, ranging from cool climatic conditions in northern Clarendon near the Manchester border, to high temperatures on the Clarendon plains (location of proposed RDA) and dry limestone forests in the Portland Bight and Brazilletto Mountains.

It is not assumed that the proposed RDA will contribute negatively to aesthetics of the area since the location is behind the existing RDAs and away from the natural lines of sight of the majority of residential communities in the area.

3.2 GEOLOGY

The area under consideration is in the district of Halse Hall, in southern Clarendon. It can be located on the 1:50,000 topographic Sheet 17 (metric edition) at co-ordinates 245385 (Figure 3-1: Geology Map of Southern Clarendon). Geomorphologically, the area lies on the gently sloping alluvial fan of the Rio Minho. The apex of the fan, at May Pen, lies at an altitude of about 70 m above sea level (asl), although the present river bed is incised into the fan, being at about 50 m asl at May Pen. From May Pen the river flows over a straight line distance of about 20 km to the sea. In the vicinity of Hayes, at the confluence with Webbers Gully, the river bed lies at an altitude of 38 m asl, while the plant and RDAs at Hayes, east of the river, lie on an old, dissected terrace remnant at elevations of 45 to 50 m asl with flat to gently undulating topography. The terrace remnant forms a high spot between Webbers Gully, which borders the site on the north and northwest before entering the Rio Minho, and Cannons Gully which extends along the eastern side of the site, draining to the south at Bog and separating the site from the limestone plateau of Harris Savannah.

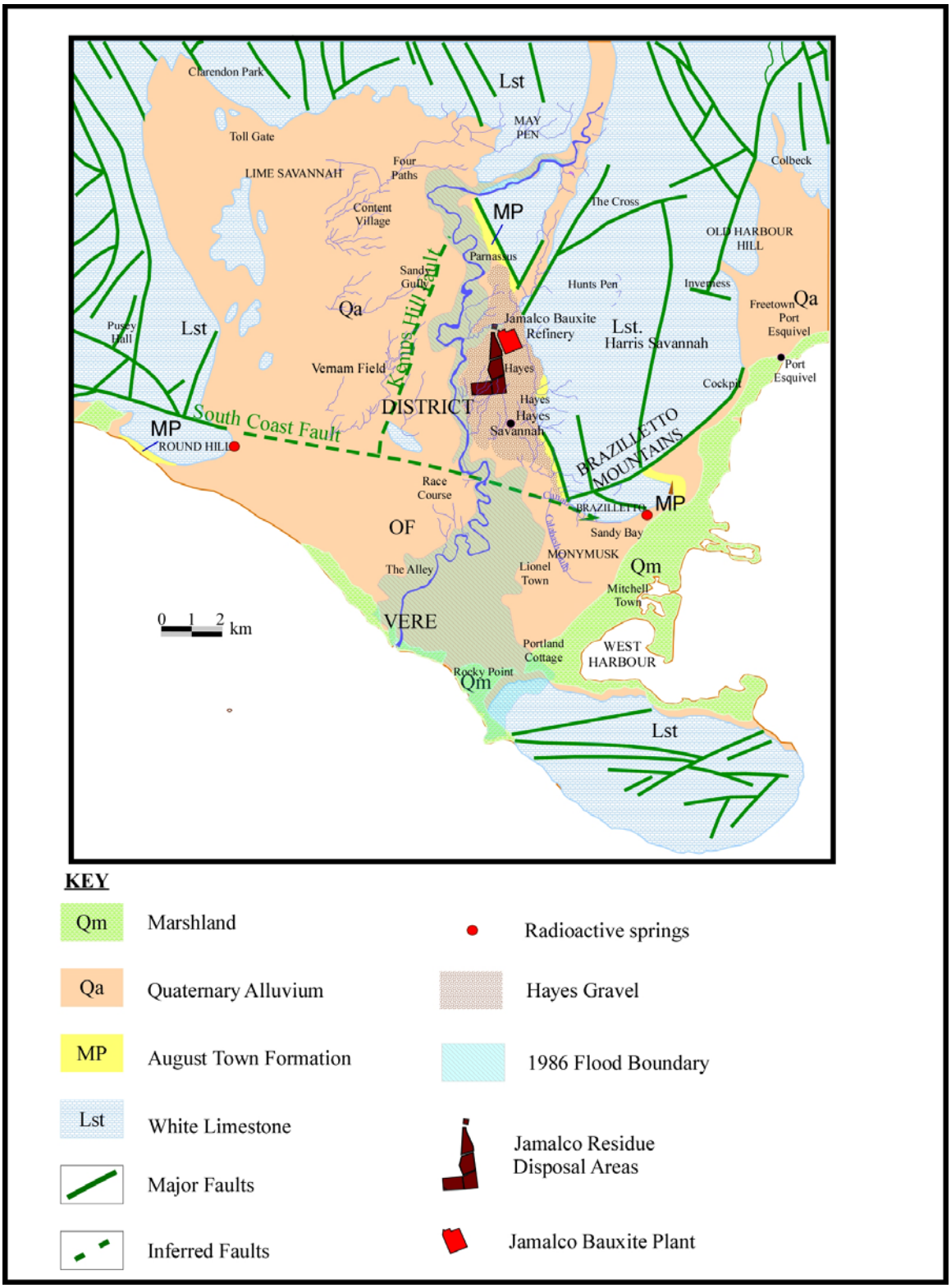


FIGURE 3-1: GEOLOGY MAP OF SOUTHERN CLARENDON

South of Hayes the alluvial fan flattens out to form what have been called the Vere Plains (Figure 3-1). Elevations over this area are low and the water table is relatively high, so that settlements such as Lionel Town and Alley are frequently flooded.

The rocks of the area consist of two main units. The various unconsolidated alluvial sediments, part of the Rio Minho fan complex, rest on limestone bedrock with a highly irregular surface.

3.2.1 THE ALLUVIAL FAN COMPLEX

The alluvial fan contains a wide range of more or less unconsolidated siliciclastic sediments. The top of the original fan, which has been extensively dissected, is preserved only in the neighbourhood of Halse Hall and Hayes (Figure 3-1). The sediments underlying the plant and RDAs make up this remnant and have been called the Hayes Gravels. The gravels range in particle size from pebbles and cobbles to silt and range in thickness from zero to 5-6 m in the north to 14-15 m in the south of the plant area (Plate 3-1). Clay is rare and the gravels are well-drained. Within the rest of the eastern part of the fan the sediments are very variable, although generally finer grained than the Hayes gravels, and with alluvial clay lenses.

PLATE 3-1: HAYES GRAVEL AT SITE OF PROPOSED RESIDUE DISPOSAL AREA

3.2.2 THE LIMESTONE BEDROCK

The sediments of the Hayes Gravels are separated from the limestone bedrock by an irregularly developed layer of clay (Figure 3-2), at least in part being a weathered palaeosol developed on the limestone surface.

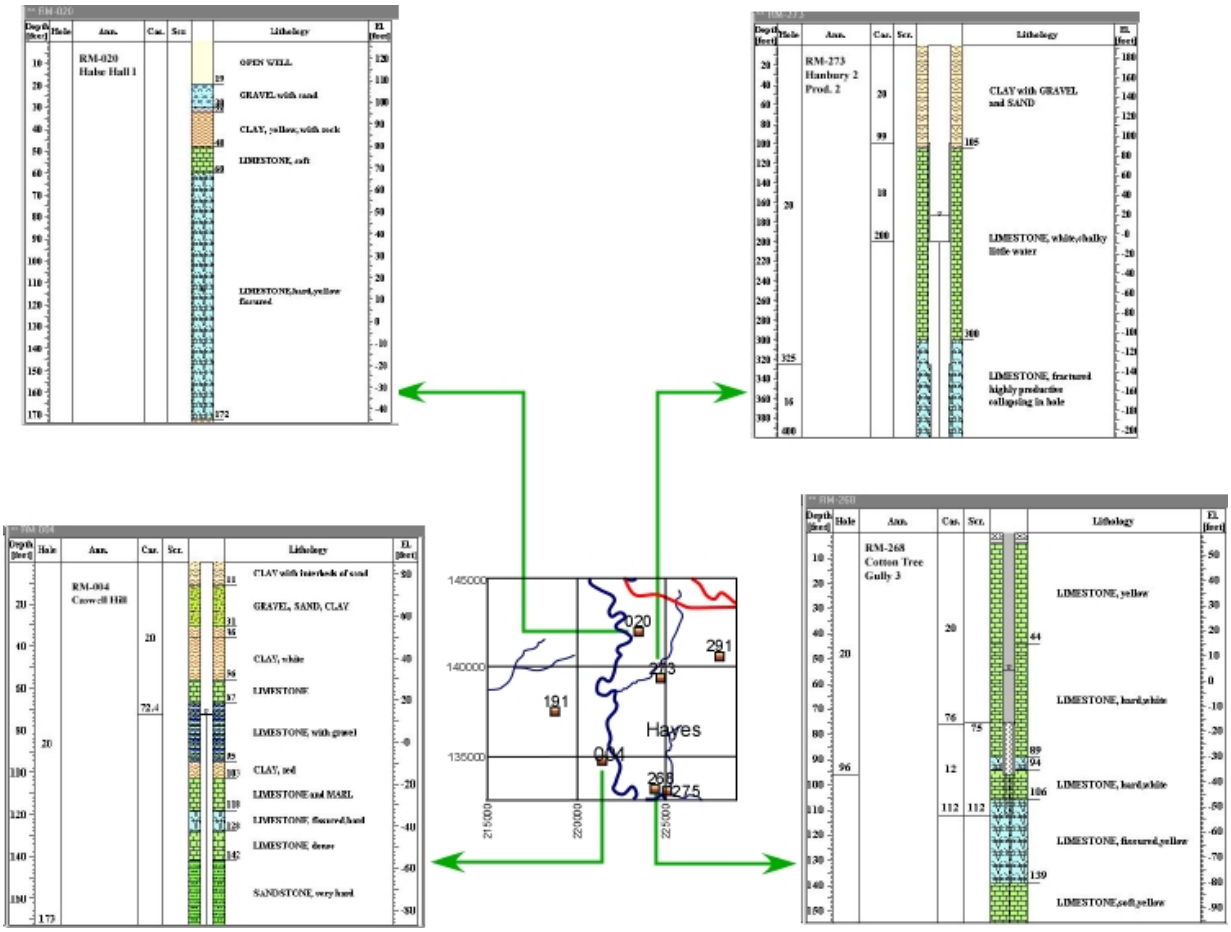


FIGURE 3-2: WELL LOGS THROUGH THE HAYES GRAVELS (SOURCE: HTTP://WWW.GEOCITIES.COM/KKARANJAC/)

The limestone has been divided by the Mines and Geology Division into the lower, relatively pure Newport Limestone (Mn on Geological Sheet 16) and the upper, less pure August Town Formation (MP). The Newport limestone consists of moderately well-bedded, compact limestones, containing frequent rubbly layers, while the August Town Formation consists of impure limestones with irregularly interbedded marly and clayey layers. These rocks are exposed along the eastern side of the alluvial fan, less than a kilometre east of the plant site.

3.2.3 GEOTECHNICAL CHARACTERISTICS

3.2.3.1 THE ALLUVIAL FAN COMPLEX

Table 3-2: **Properties of Various Soil Groups (adapted from Conrad Douglas & Associates EIA on the construction of Residue Disposal Area 4)** below shows the characteristics of materials that should be expected in the Hayes Gravels.

TABLE 3-2: PROPERTIES OF VARIOUS SOIL GROUPS (ADAPTED FROM CONRAD DOUGLAS & ASSOCIATES EIA ON THE CONSTRUCTION OF RESIDUE DISPOSAL AREA 4)

Typical Names of Soil Groups	Group Symbols	Important Properties			
		Permeability when Compacted	Shearing Strength when Compacted and Saturated	Compressibility when Compacted and Saturated	Workability as a Construction Material
Well-graded gravels, gravel sand mixtures, little or no fines.	G.W.	Pervious	Excellent	Negligible	Excellent
Poorly graded gravels, sand mixtures, little or no fines.	G.P.	Very pervious	Good	Negligible	Good
Silty Gravels, poorly graded gravel-sand-silt mixtures.	G.M.	Semi-pervious to impervious	Good	Negligible	
Clayey gravels, poorly graded gravel-sand-clay mixtures.	G.L.	Impervious	Good to fair	Very low	Good
Well-graded sands, gravelly sands, little or no fines.	S.W.	Pervious	Excellent	Negligible	Excellent
Poorly graded sands, gravelly sands, little or no fines	S.P.	Pervious	Good	Very Low	Fair
Silty sands, poorly graded sand-clay mixtures	S.M.	Semi-pervious to pervious	Good	Low	Fair

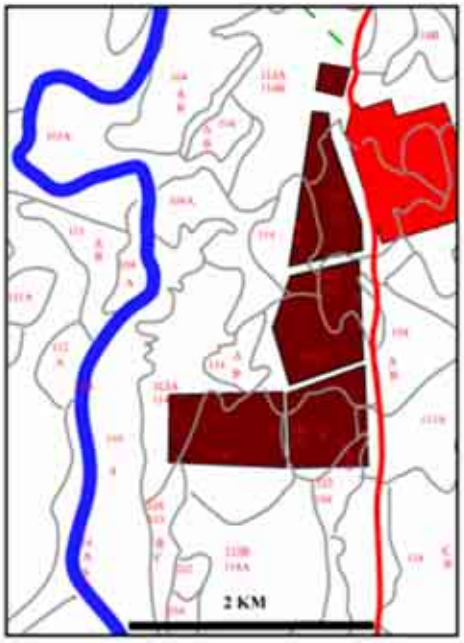
In summary the gravels tend to be pervious to very pervious with good to excellent shear strength, of negligible compressibility and good to excellent workability as a construction material. Alluvial materials sourced from other places in the Rio Minho fan should also be well suited for construction after washing and grading.

The limestone bedrock of the area may be thickly stratified and massive, but contains frequent zones of less competent, rubbly and marly limestone. There may be a case-hardened layer up to several metres thick, over the softer limestone, where it has been indurated from weathering. The rubbly zones are frequently the result of brecciation associated with faults. Solution features consist of joints widened by solution and there may be cave development. Most large features in the limestones of southern Clarendon and St. Catherine consist of vertical shafts with widening laterally into extensive cave complexes in some areas, such as Portland Ridge (Fincham, 1997).

In summary the bearing capacity of the limestone bedrock is good, although for large structures the presence or absence of caverns or fissures at shallow depth should be ascertained.

3.2.3.2 SOILS

The soils of the Hayes region are intimately associated with the alluvial deposits of the Rio Minho Fan Complex. Figure 3-3 indicates the distribution of the different soils of the area. In Figure 3-3: SOILS MAP OF HAYES, CLARENDON the classification follows that used by the Ministry of Agriculture, the symbol group representing the soil type and steepness of slopes.



SOIL TYPES

24	Agualta Sandy Loam
103	Agualta Loam
104	Agualta Clay
111	New Yarmouth Loam
112	New Yarmouth Clay Loam
113	Halse Hall Clay
114	Halse Hall Clay (Red Phase)
202	Rhymsbury Clay

SLOPE CATEGORIES

A	0 - 2 Degrees (0% - 5%)
B	2 - 5 Degrees (5% - 11%)
C	5 - 10 Degrees (11% - 22%)

FIGURE 3-3: SOILS MAP OF HAYES, CLARENDON

3.2.4 MINERAL RESOURCES

The only mineral resources of note are the limestone forming the Harris Savannah plateau, which has been used as a source of marl and crushed stone from the disused quarry near Halse Hall, and the sand and gravel extraction industry in the bed and flood plain of the Rio Minho. The Hayes Gravels contain small pebbles and occasional larger cobbles of the semiprecious stone jasper (Porter et al. 1982; Porter, 1990). Rarely fragments of silicified wood may be collected.

3.3 HYDROGEOLOGY AND HYDROLOGY

3.3.1 HYDROGEOLOGY

3.3.1.1 HYDROSTRATIGRAPHY

The Clarendon Alumina Works consisting of the bauxite/alumina plant and the Residue Disposal Areas (RDAs) owned by Jamalco is located within the parish of Clarendon on the south central coast of the island (Figure 3-4: Basin Location). The parishes of Clarendon and Manchester together form the Rio Minho Hydrologic Basin that consists of the Rio Minho, the Milk River and the Gut-Alligator Hole Watershed Management Units (Figure 3-5).

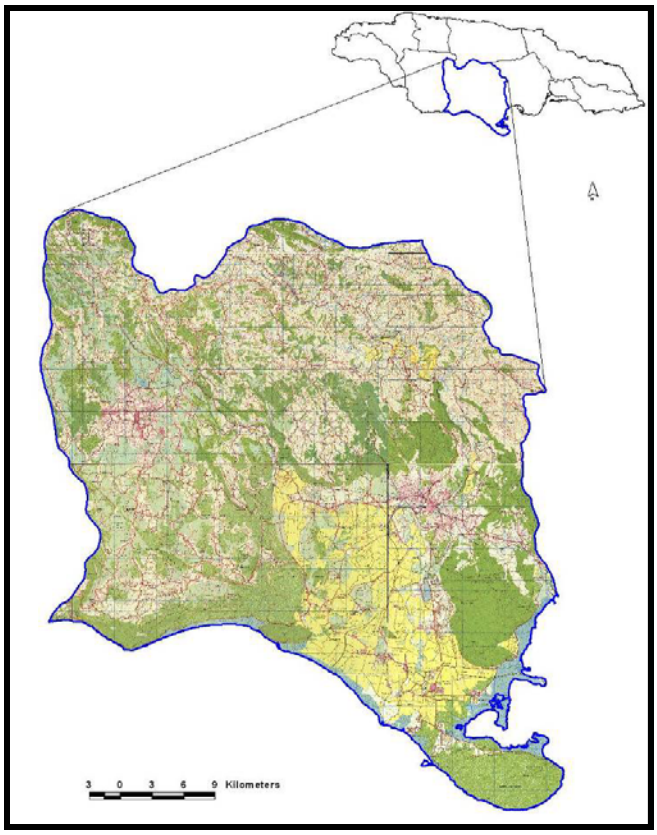


FIGURE 3-4: BASIN LOCATION

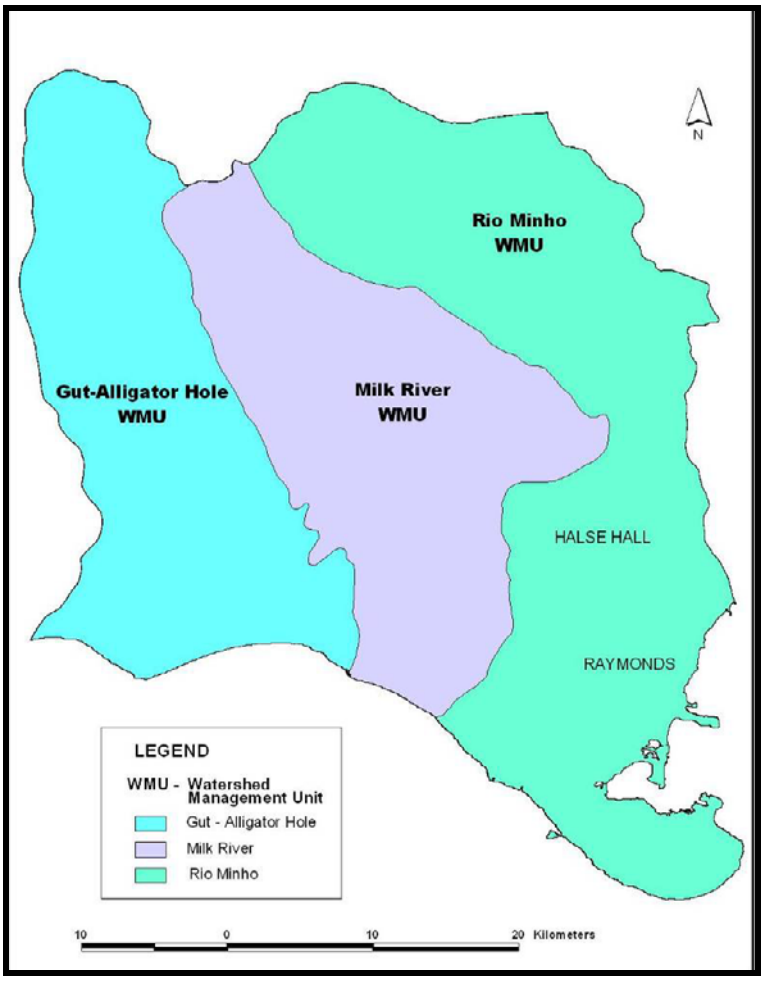


FIGURE 3-5: Basin Watershed Management Units

The Rio Minho Hydrologic Basin extends over an area of 1,705 km2 (Figure 3-4). The Basin is subdivided into 3 sub-basins and 3 hydrostratigraphic units (Figure 3-6). Table 3-3 below summarizes the area for each catchment.

Figure 3-6: Hydrostratigraphy Map of Project Areas

TABLE 3-3: AREAS of the Hydrostratigraphy Units of the Sub-divisions of the Rio Minho Hydrologic Basin

Sub-basins	Hydrostratigraphic Units (km^2)			Total	Percent
	Basement Aquiclude	Limestone Aquifer	Alluvium Aquifer (Aquiclude)		
Upper Rio Cobre	362	31	NIL	393	23
Clarendon Plains	6	528	415	949	56
Manchester Highlands	NIL	358	(5)	363	21
Total	368	917	420	1,705	----
Percent	22	54	24	----	100

3.3.1.2 HYDROGEOLOGIC CHARACTERISTICS

The REFINERY is located within the Clarendon Plains subdivision (Rio Minho Watershed Management Unit) atop the limestone aquifer (Figure 3-7). The limestone formation is a member of the White Limestone Group of Tertiary Age (7-28 million years). The alluvium of Pleistocene Age (2 million years) has been deposited atop the limestone (Figure 3-8).

FIGURE 3-7: Location of REFINERY

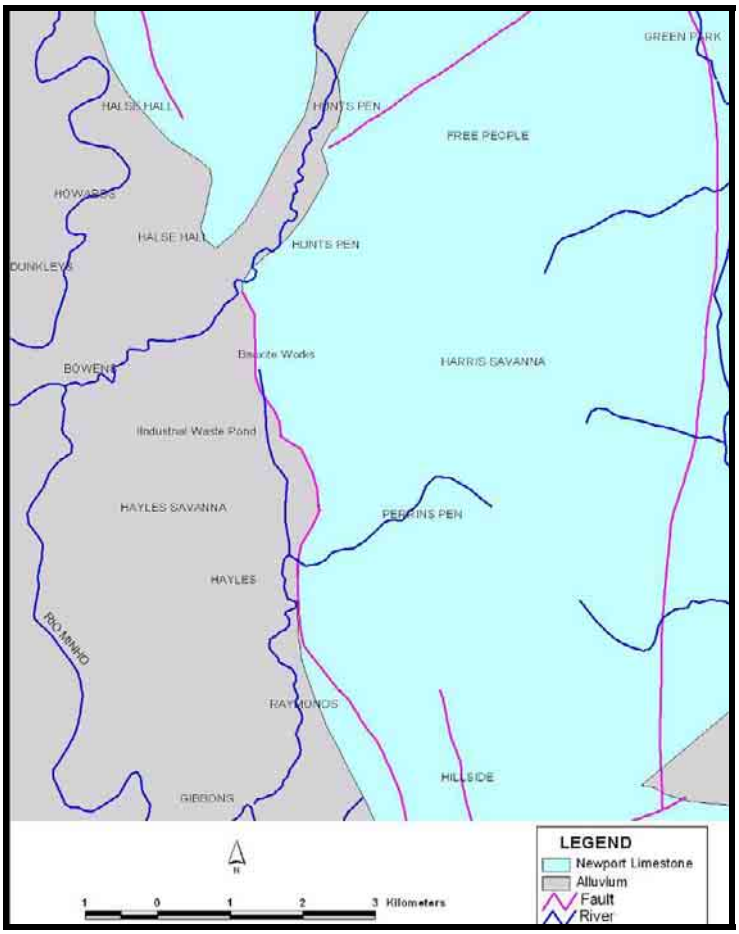


FIGURE 3-8: Geology of Area

The White Limestone acts as a single hydrogeological unit. The main member the Newport Formation covers most of the Rio Minho basin to a considerable depth. It outcrops in the hills of the Brazilletto Mountains and underlie the alluvium of the plains, where it is the principal source of groundwater. The exact thickness of the limestone is not known but the UNDP/FAO water resources project estimated that in the southern area of the basin the thickness exceeds 1,200 metres as proven by an exploratory oil well drilled at Portland Point.

The primary limestone formation under the refinery is the Newport Limestone Formation. This formation extends throughout the Rio Minho Basin and is the major aquifer that provides water to the wells that support irrigation, domestic and industrial water in the parish. The Newport is essentially a micrite and in its lowest horizon is characterized by an abundance of corals. The majority of the monitor wells drilled by Jamalco penetrated the middle to lower horizons of the Newport Limestone as marked by the abundance of fossils such as gastropods, corals and bivalves.

The limestone aquifer is very permeable and of high transmissivity. The Dry River 5R well yielded 8722 m^3/day with a drawdown in the water table of 0.27 metre. The specific capacity, an indication of the wells performance, was 32, 304 m^3/day per metre of drawdown. The transmissivity of the limestone was calculated from the pumping test information as 15,200 m^2/d (15, 200 m^3/day/m).

The high permeability is demonstrated by the loss of circulation (drill water) during the drilling, the drop of the drill string as cavities were encountered and the high yield/low drawdown of the monitor wells when tested using a compressor as a pumping unit. The wells drilled in the vicinity of the REFINERY encountered the water bearing horizons at 13 to 16 metres below sea level. The saturated thickness of the limestone in the area is estimated to be in excess of 150 metres as proven by the Vernamfield well drilled into the same central depression atop which the REFINERY is located. At the final drill depth of the monitor wells there was evidence of high secondary permeability and the saturated thickness was in excess of 110 metres.

The alluvium atop the limestone consists mostly of sands, gravels and clays. The alluvium also fills the fault-incised channels in the underlying limestone. One such channel approximates the course of the Rio Minho. The alluvium thickens southwards from Bowens. The coarser sediments are concentrated within the buried channel and along the course of the Rio Minho. Monitor Well 5 located on the banks of the Rio Minho west of the RDA proved a thickness of 17 metres of coarse sand and gravel with clay between 15 to 17 metres. Examination of the lithologic logs from the monitor wells drilled around the REFINERY indicates a basal layer of clay separating the alluvium from the underlying limestone. The Alcoa No. 1 borehole located at E4655 N3618 encountered 10 metres of white sticky clay atop the limestone. The alluvium in the vicinity of the REFINERY is dry and no water was encountered during the drilling of the monitor wells. The alluvium is unsaturated and functions as an aquiclude (Geomatrix Jamaica Ltd. 1995).

3.3.1.3 STRUCTURE

The area around the REFINERY is a large limestone depression criss-crossed by several faults. The lateral and vertical movements along these faults are responsible for the variation in lithology encountered during the drilling of the monitor and production

wells i.e. lower, middle or upper Newport Limestone Formation. Faults that cross the area and trend northeast to southwest and northwest to southeast truncate at the boundary of the alluvium. The faults are buried beneath the alluvium but if extrapolated would meet north of the Webbers Gully at New Bowens settlement. One fault trending northwest to southeast passes east of the bauxite/alumina plant and has incised a deep channel within the limestone. The thickened alluvium encountered in Hanbury No 2R well and Monitor Well 3 mark this fault zone. This fault reappears at Raymonds to the south of Hayes Township where it abuts onto the South Coastal Fault (Figure 3-8).

The UNDP/FAO Water Resources Assessment of the Rio Minho-Milk River Basin, Annex II-Water Resources Appraisal divides the basin into 3 units and treats each unit as being separate. The boundary between Units B and C was said to be a groundwater divide at the western edge of the Brazilletto Mountains until it intersects the South Coastal Fault, which for all purposes is the southern boundary of the limestone aquifer. While there is no evidence for the groundwater divide the fault that is located east of the plant could be the eastern boundary of Unit B.

Cross sections drawn in a north-south and east-west direction across the Halse Hall area show the following:

- The erosional (wavy) surface of the limestone
- The variation in thickness of the alluvium
- The basal clay layer at the limestone/alluvium boundary; and
- The water table in the limestone aquifer.

The cross sections are shown as Figure 3-9 and Figure 3-10

FIGURE 3-9: CROSS-SECTION – EAST-WEST DIRECTION ACROSS THE HALSE HALL AREA

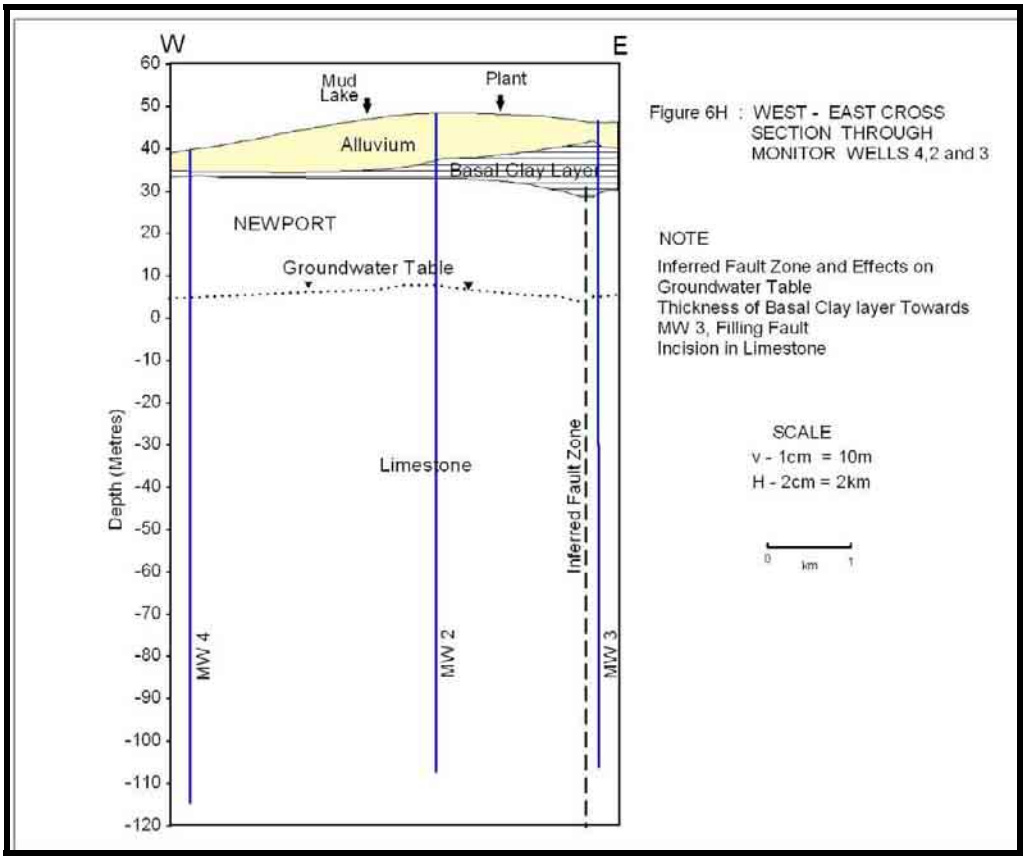
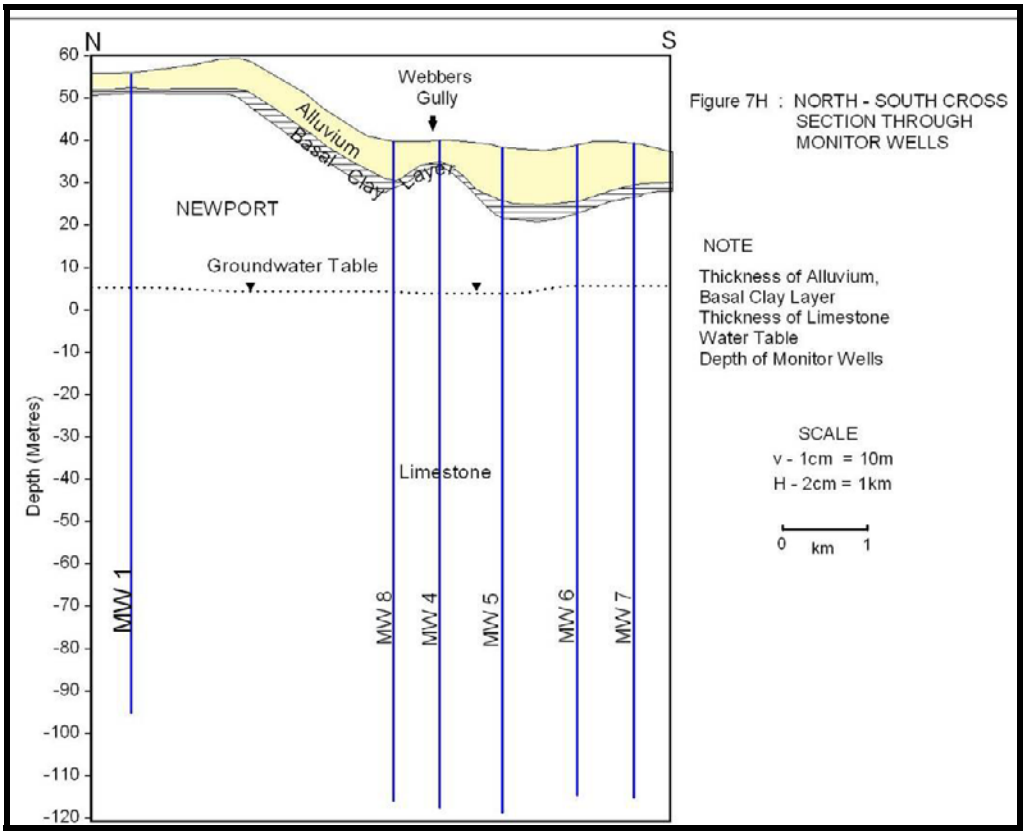


FIGURE 3-10: CROSS-SECTION – NORTH-SOUTH DIRECTION ACROSS THE HALSE HALL AREA



3.3.1.4 TOPOGRAPHY AND DRAINAGE

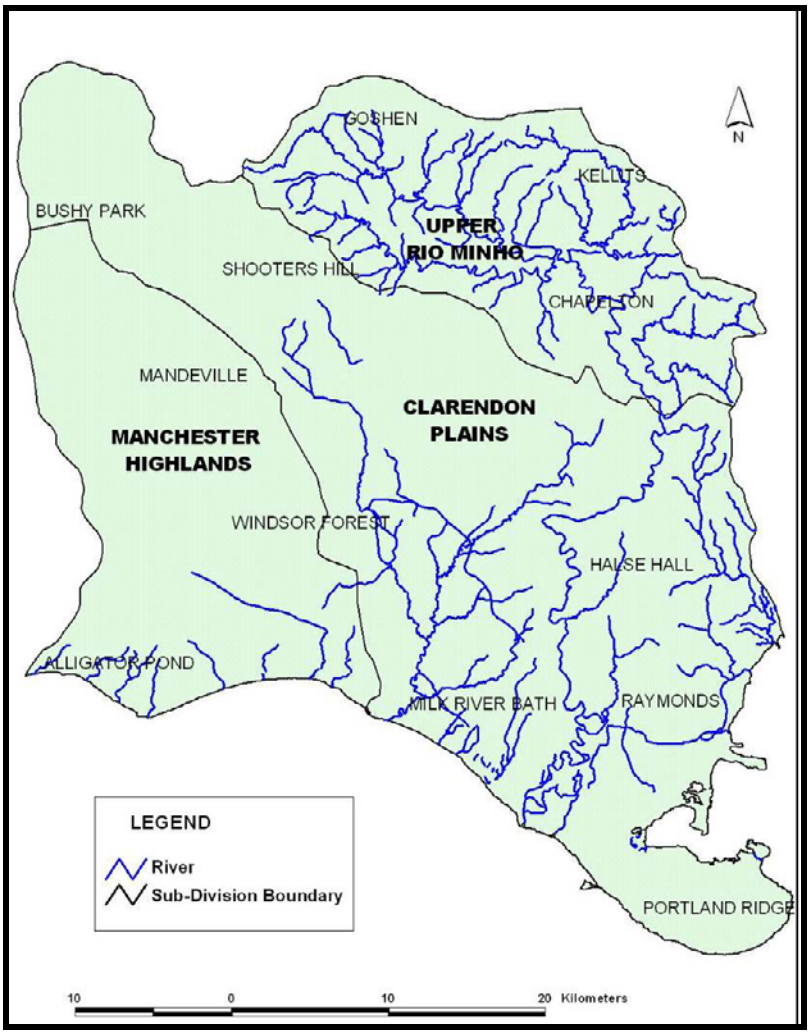
Topographically the area is of low relief with gentle rolling hills on the Harris Savannah. The Brazilletto Mountains form the high ground rising to 250 metres above mean sea level to the east of the bauxite/alumina plant. The Rio Minho flows in a north-south direction west of the RDAs and is the major surface water drainage system. The Webbers Gully, a tributary of the Rio Minho, drains the area north of the Plant. The Webbers Gully is seasonal and carries storm water from the northeast section of the basin into the Rio Minho. During high rainfall events when the Rio Minho is in spate its stage is higher than that of the Webbers Gully with the result that the gully cannot enter the river and will overtop its banks with resultant flooding. The Webbers Gully was straightened to facilitate the construction of the RDA 1 (Mud Lake) and the Clear Lake. The Webbers Gully flows between the northern dike of the RDA 1 and the southern edge of the Clear Lake. Monitor well 8 is located just south of the Webbers Gully before it joins the Rio Minho.

3.3.2 HYDROLOGY

3.3.2.1 SURFACE WATER HYDROLOGY

The hydrologic sub-division of the Rio Minho basin is shown as Figure 3-11.

FIGURE 3-11: Hydrologic Sub-Division of the Rio Minho BASIN



The Rio Minho and the Webbers Gully are the main constituents of the surface water hydrologic system in the Halse Hall area. The Webbers Gully has a sub-basin that covers an area of approximately 17.8km^2.

The Rio Minho, located west of the RDAs, flows in a north-south direction. The Webbers Gully, a tributary of the Rio Minho, drains the area between New Bowens and the plant site. The alluvium filled Webbers Gully joins the Rio Minho Valley through Palmers Cross

at the Barrel Hole sink west of Chateau, May Pen. It joins the Rio Minho at Old Bowens flowing north of Monitor well 8.

The Rio Minho and the Webbers Gully are seasonal in flow. The Rio Minho is seasonal between May Pen and Alley. The river loses its flow-an average of 20 million cubic metres per year (MCM/yr) - just north of May Pen to the limestone aquifer. At Alley the river becomes perennial and is sustained by wet season surface water throughflow from the Upper Rio Minho sub-basin (111 MCM/yr) and perennial inflow of irrigation return water (22 MCM/yr), totalling 133 MCM/yr average discharge to the sea. There is no significant contribution to the Rio Minho throughout its passage across the Clarendon Plains sub-basin to the sea.

Ponding of water occurs along the course of both surface water systems. The ponding indicates the effectiveness of the basal clay layer in preventing vertical movement of water through the alluvium to the limestone aquifer. However along the Webbers Gully in the vicinity of the clear lake there are outcroppings of limestone. Surface flow as well as any contaminant can enter the limestone aquifer through these surface exposures of limestone.

3.3.2.2 GROUND WATER HYDROLOGY

Ground water is water that is stored within the saturated section of the limestone formation. The natural level of the water i.e. the water table marks the upper section of this zone of saturation. Rainfall is the sole source of recharge to the ground water system but artificial, intentional or unintentional, inflows can also contribute and may affect ground water type and quality. The impact will depend on several factors and may include.

- Hydrostratigraphy
- Permeability
- Water levels
- Flow direction

As stated above in section 3.3.1.1 the two main hydrostratigraphic units within the project area are the limestone aquifer and the alluvium aquifer/aquiclude. The alluvium is unsaturated and does not function as an aquifer. It can for all purposes be classified as an aquiclude.

A hydrostratigraphic unit is a geologic formation (or series of formations), which demonstrates a distinct hydrologic character. An aquifer is a geologic formation or group of formations that readily and perennially yields water to a spring or well. An aquiclude is the opposite of an aquifer.

The alluvium overlies and confines the limestone aquifer within the project area. The full penetration of the alluvium during the well drilling operations proved its lack of water. The limestone aquifer was partially penetrated to a thickness of 135 metres out of a reported thickness of 1350 metres-10% only. Yet this was the deepest drilling to have been done in the area. The confinement of the aquifer was evident in the drilling of the monitor wells where artesian rises in the water level of up to 14 metres were noted (Geomatrix 1995).

Ground water is ponded within the karstic Clarendon Plains limestone aquifer by clayey alluviums on the downfaulted southern block of the South Coastal Fault. Along its southeastern boundary alluviums and underlying coastal aquicludes act as a barrier to direct outflow to the sea. Note the change (increase) in the elevation of the water table just behind the fault as shown in Figure 3-12.

The alluvium south of the South Coastal Fault is an aquifer and is tapped by the Sugar Company of Jamaica using tube wells to provide irrigation and domestic water to its operations at Monymusk. The thickness of the alluvium in this area was determined in 1978 using a gravity survey (Bouguer Anomaly) to be a maximum of 650 metres (Wadge, Brooks and Royall 1983).

3.3.3 WATER RESOURCES

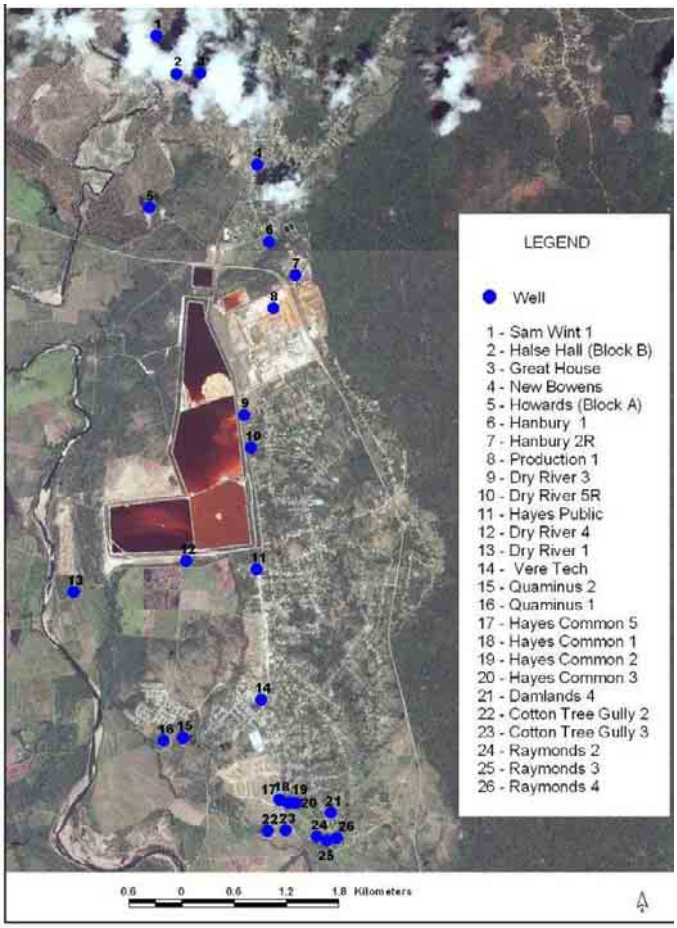
3.3.3.1 WELL LOCATIONS AND YIELDS

There are no hydraulic structures on the Rio Minho River in the vicinity of the proposed site for the development of additional RDAs.

The seasonal character of the main rivers in the Basin combined with the high agricultural demand account for the heavy reliance on ground water. Wells tapping the limestone aquifer produce water for agricultural, domestic and industrial uses. At present over 80% of the water supplied in the basin is from ground water.

There are 26 production wells tapping the limestone aquifer, located east of the Rio Minho River within the Clarendon Plains sub-division and to the north (from Halse Hall Great House) and south (to Raymonds) of the REFINERY. A list of these wells, the owners, their use and licensed/historical yield is given in Table 3-4 below. The locations of these wells are shown in Figure 3-12.

FIGURE 3-12: Location of Production Wells



The greater numbers of the wells is located south of the REFINERY, are all owned by SCOJ, are all used for irrigation and are centered on the Hayes Common-Raymonds area. The location of these wells is along the South Coastal fault that is open to the sea at the western and eastern ends. The high permeability associated with the fault and the ponding of groundwater behind the fault influenced the locations. The wells located along the fault are high producers.

Of these 26 wells the Sugar Company owns 14 that are used for irrigation purposes; the National Water Commission owns 2 for Public Water Supply; the Ministry of Education owns 1 for agricultural uses and Jamalco owns 9 for private domestic, agricultural and industrial uses. The wells owned by Jamalco and used for agricultural purposes are leased to a farming entity.

The total licensed abstraction for the wells owned by Jamalco total 83,830 cubic metres per day (m3/d); that for the National Water Commission totals 10,130 m^3/d; that for the Ministry of Education (Vere Technical well) totals 1,690 m^3/d and the historical abstraction for the Sugar Company of Jamaica (SCoJ) totals 131,112 m^3/d. One well, Quaminus 2, is shared between the NWC and the SCoJ. The NWC purchases water from this well to meet the demands of the Hayes New Town.

The total licensed or historical entitlement of abstraction from the area around the REFINERY is 226,762 m^3/day.

TABLE 3-4: List of Production Wells East of the Rio Minho and within the Vicinity of the REFINERY

Name of Well	Name of Owner	Water Use	Yield (m^3/day)
Great House	Jamalco	Private Domestic	250
Sam Wint	Jamalco	Agriculture	7,560
Halse Hall (Block B)	Jamalco	Agriculture	11,160
Howrads (Block A)	Jamalco	Agriculture	10,880
Dry River 3	Jamalco	Industrial	9,815
Dry River 5R	Jamalco	Industrial	9,815
Hanbury 1	Jamalco	Industrial	8,184
Hanbury 2R	Jamalco	Industrial	10,902
Production 1	Jamalco	Industrial	15,264
New Bowens	National water Commission	Public Supply	3,272
Hayes Public	National water Commission	Public Supply	6,858
Vere Technical	Ministry of Education	Agricultural/Domestic	1,690
Hayes Common 1	Sugar Company of Jamaica	Irrigation	11,088
Hayes Common 2	Sugar Company of Jamaica	Irrigation	13,944
Hayes Common 3	Sugar Company of Jamaica	Irrigation	10,224
Hayes Common 5	Sugar Company of Jamaica	Irrigation	11,088
Quaminus 1	Sugar Company of Jamaica	Irrigation	15,936
Quaminus 2*	Sugar Company of Jamaica	Irrigation	8,184
Cotton Tree Gully 2	Sugar Company of Jamaica	Irrigation	9,168
Cotton Tree Gully 3	Sugar Company of Jamaica	Irrigation	9,096

Name of Well	Name of Owner	Water Use	Yield (m^3/day)
Damlands 4	Sugar Company of Jamaica	Irrigation	2,760
Raymonds 2	Sugar Company of Jamaica	Irrigation	6,072
Raymonds 3	Sugar Company of Jamaica	Irrigation	9,168
Raymonds 4	Sugar Company of Jamaica	Irrigation	10,200
Dry River 1	Sugar Company of Jamaica	Irrigation	9,168
Dry River 4	Sugar Company of Jamaica	Irrigation	5,016

*- well shared between SCoJ and NWC.

In addition to the 26 production wells there are two disused production wells, Dry River 2 and Dry River 6, as well as twelve (12) monitor wells located around the REFINERY. Of the 12 monitor wells one has been destroyed (Monitor Well 7) and one has become inaccessible due to expansion of the plant.

The 12 monitor wells were drilled in 2 phases. Phase 1 saw 8 wells being completed in 1994 with a further 4 wells in phase 2 being completed in 1997. The locations of the monitor wells are shown as Figure 3-13.

FIGURE 3-13: Location of the Monitor Wells

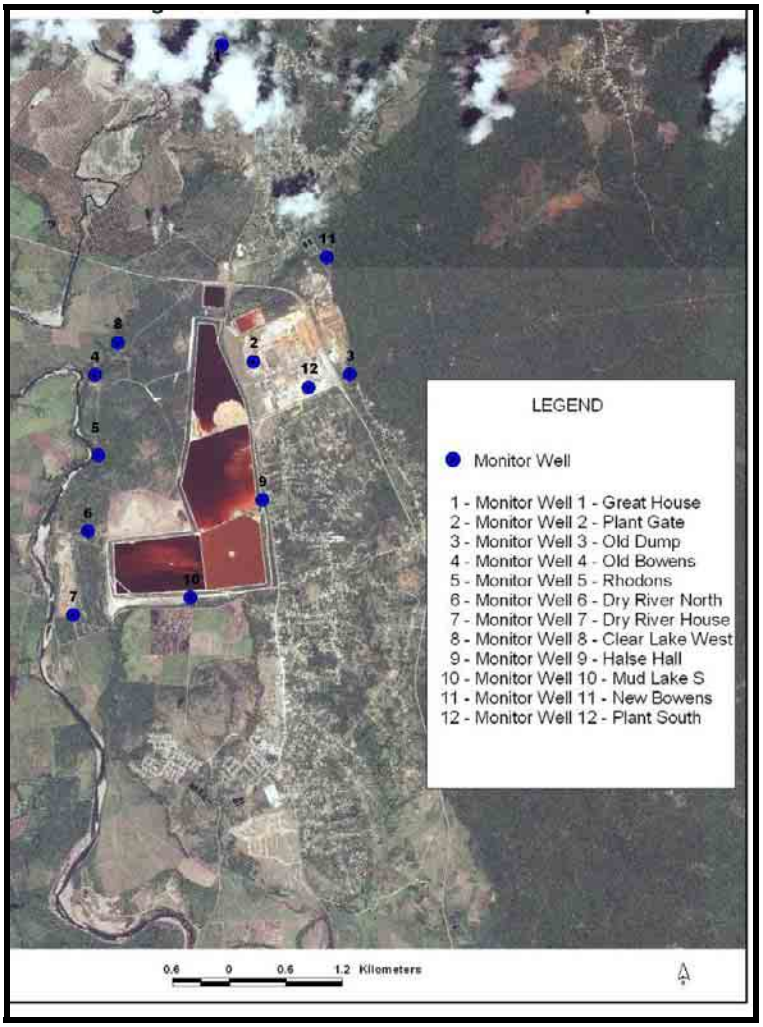


TABLE 3-5: Construction Details of Monitor wells-Jamalco-REFINERY (MS-MEDIUM SAND FS-FINE SAND)

Monitor Well		Drill Hole		Casing/Screen					Filter Pack				Seal	Cement Grout
No.	Name	Dia. (cm)	Depth (m)	Type	Dia. (cm)	From (m)	To (m)	Length (m)	Type	From (m)	To (m)	Thickness (m)		
1	Great House	10.16	152.4	Blank Screen Bank	5 5 5	+0.3 146.3 149.3	146.3 149.3 152.4	146.6 3.0 3.1	MS FS MS	-1.5 141.7 143.2	141.7 143.2 152.4	140.2 1.5 9.2	141.7	1.5 0 to 1.5
2	Plant Gate	10.16	155.4	Blank Screen Bank	5 5 5	+0.3 149.3 152.4	149.3 152.4 155.4	149.6 3.1 3.0	MS FS MS	-1.5 140.2 143.2	141.7 143.2 155.4	140.2 3.0 12.2	141.7	1.5 0 to 1.5
3	Old Dump	10.16	155.4	Blank Screen Bank	5 5 5	+0.3 149.3 152.4	149.3 152.4 155.4	149.6 3.1 3.0	MS FS MS	-1.5 144.8 146.3	144.8 146.3 155.4	143.3 1.5 9.1	144.8	1.5 0 to 1.5
4	Old Bowens	10.16	155.4	Blank Screen Bank	5 5 5	+0.3 149.3 152.4	149.3 152.4 155.4	149.6 3.1 3.0	MS FS MS	-1.5 144.8 146.3	144.8 146.3 155.4	143.3 1.5 9.1	144.8	1.5 0 to 1.5
5	Rhodons	10.16	155.4	Blank Screen Bank	5 5 5	+0.3 149.3 152.4	149.3 152.4 155.4	149.6 3.1 3.0	MS FS MS	-1.5 144.8 146.3	144.8 146.3 155.4	143.3 1.5 9.1	144.8	1.5 0 to 1.5
6	Dry River North	10.16	152.4	Blank Screen Bank	5 5 5	+0.3 146.3 149.3	146.3 149.3 152.4	146.6 3.0 3.1	MS FS MS	-1.5 143.3 144.8	143.3 144.8 152.4	141.8 1.5 7.6	143.3	1.5 0 to 1.5
7	Dry River House	10.16	155.4	Blank Screen Bank	5 5 5	+0.3 149.3 152.4	149.3 152.4 155.4	149.6 3.1 3.0	MS FS MS	-1.5 143.3 144.8	143.3 148.8 155.4	143.3 1.5 10.6	143.3	1.5 0 to 1.5
8	Clear Lake West	10.16	155.4	Blank Screen Bank	5 5 5	+0.3 149.3 152.4	149.3 152.4 155.4	149.6 3.1 3.0	MS FS MS	-1.5 143.3 146.3	143.3 146.3 155.4	141.8 3.0 9.1	143.3	1.5 0 to 1.5
9	Halse Hall	10.16	155.4	Blank Screen Bank	5 5 5	+0.6 128.0 131.0	128.0 131.0 134.0	128.6 3.0 3.0	MS FS MS	-1.5 127.5 134.0	127.5 134.0 155.4	126.0 6.9 21.0	126.5	1.5 0 to 1.5

Monitor Well		Drill Hole		Casing/Screen					Filter Pack				Seal	Cement Grout
No.	Name	Dia. (cm)	Depth (m)	Type	Dia. (cm)	From (m)	To (m)	Length (m)	Type	From (m)	To (m)	Thickness (m)		
10	Mud Lake South	10.16	155.4	Blank Screen Bank	5 5 5	+0.8 146.3 149.3	146.3 149.3 152.3	147.1 3.0 3.0	MS FS MS	-1.5 140.0 152.4	140.0 152.4 155.4	138.5 12.4 3.0	140.0	1.5 0 to 1.5
11	New Bowens	10.16	155.4	Blank Screen Bank	5 5 5	+0.8 149.4 152.4	149.4 152.4 155.4	150.2 3.0 3.0	MS FS MS	-1.5 122.0 154.0	122.0 154.0 155.4	120.5 32.0 1.4	121.5	1.5 0 to 1.5
12	Plant Site South	10.16	152.4	Blank Screen Bank	5 5 5	+0.4 137.2 140.2	137.2 140.2 143.2	137.6 3.0 3.0	MS FS MS	-1.5 91.5 143.2	91.5 143.2 155.4	90.0 51.7 12.2	90	1.5 0 to 1.5

Each well was drilled to a depth of 155.4 metres and completed with 5 cm diameter PVC casing and screen. The annular space of each well was packed with gravel and coarse sand. The screened area, which was close to the bottom of the well, was packed off using bentonite as a seal. Development was carried out using a compressor as the pumping unit. Water samples were collected every 30 metres to develop a water quality profile with depth. The locations of the monitor wells are shown on Figure 3-10

Details on the construction of the monitor wells are given in Table 3-5 above.

3.3.3.2 GROUNDWATER LEVELS

Groundwater level (elevation of water table above sea level) is monitored monthly by Jamalco staff at each of the 10 accessible monitor wells. The groundwater table fluctuates seasonally with recharge and abstraction/discharge. When recharge exceeds abstraction/recharge the storage increases and the water table rises. When abstraction/discharge exceeds recharge water is taken from storage and the water table elevation will decline. In the dry season the water table elevation in the area around the REFINERY varies from 2.40 to 4.10 metres above sea level with the highest level being recorded at Monitor Well 1 to the north.

The year 2003 was one of high water table elevations as the recharge from the extreme rainfall events in May/June and September of 2002 increased storage within the limestone aquifer. Water table elevations around the REFINERY remained higher than 6 metres above sea level for all of 2003. In fact at two wells, monitor wells 1 and 12, the water table elevation was higher than 7 metres above sea level. This has gradually declined and in April of 2004 the water table elevations varied from a high of 5.34 (in the north of the area) to a low of 4.51 (west of the RDAs) metres above sea level. There has not been a decline in the groundwater table since the measurements began in 1998.

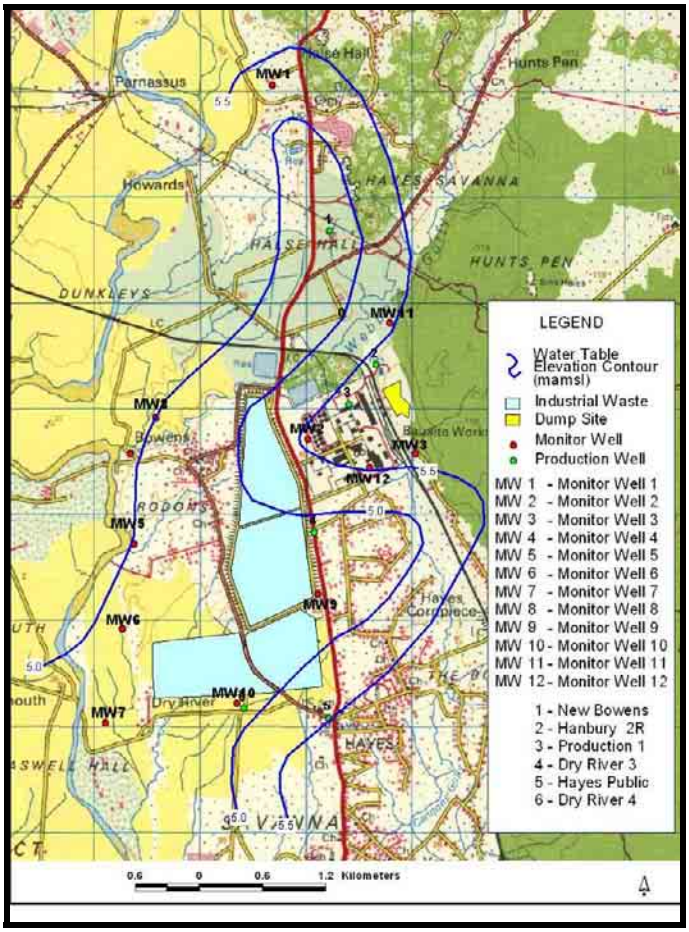
The water table elevation upon completion of the monitor wells and that on April 1, 2004 is compared in Table 10 below.

Table 3-6: COMPARISON OF WATER TABLE ELEVATIONS FOR THE MONITOR WELLS

Name of Well	Water Table Elevation (M asl)		Remarks
	Upon Completion	April 2004	
Monitor Well 1	3.35	5.20	MW 1-8 completed
Monitor Well 2	4.63	5.63	In 1994
Monitor Well 3	4.23	5.23	
Monitor Well 4	4.37	4.95	
Monitor Well 5	3.85	4.97	
Monitor Well 6	3.79	4.51	
Monitor Well 8	3.84	4.97	
Monitor Well 9	3.91	4.80	MW 9-12 completed
Monitor Well 10	3.87	4.81	In 1997
Monitor Well 11	3.79	5.34	
Monitor Well 12	3.87	7.38*	*June 2004

The water table elevation map for April 2004 is shown as Figure 3-14. The groundwater table elevation shows a high of just over 6 metres above sea level. The direction of flow is from the high to the low elevation and is from north to south through the REFINERY.

FIGURE 3-14: Water Table Elevation Map



3.3.3.2.1 DISCHARGE

Knowledge of the discharge to the sea via the limestone south of the South Coastal Fault is not known. There is no evidence to show that there is a discharge along this reach to the sea. The actual discharge into the sea may be some distance offshore where the White Limestone is exposed to the seabed. It is possible that outflow may be restricted to those periods of high water table and marine discharge in normal conditions may be small.

The principal discharge from the aquifer is by abstraction from pumped wells. In Table 3-4 a list of the pumped wells is given with the licensed or historical abstraction rates.

The total committed water for abstraction from the area around the REFINERY was 226,762 m^3/day (10.30 x 108 imperial gallons per day). There has never been a period when all the wells have been abstracting at their maximum and the 226,762 m3/day was

being abstracted. This area of the limestone aquifer has the greatest abstraction in the basin and is concentrated in particular to the area south of the REFINERY that includes the Hayes Common-Raymonds area. Many of the wells suffer from saltwater contamination either from penetration of the fresh water-seawater interface along the South Coastal Fault, the movement of saltwater (influenced by the pumping) along the fault that is open to the sea at both the western and eastern ends or the recirculation of return saline irrigation water.

3.3.3.2.2 RESERVOIR VOLUME

The effective ness of an aquifer to supply water on a reliable basis is determined by the volume of the reservoir rock capable of holding the water. The effective volume of the reservoir is that amount of water that the rock will yield.

The thickness of the permeable section of the aquifer in the northern area of the basin is not known. However this is determined by the depth to the impermeable basement rocks (Yellow Limestone or Volcanic rocks) and the aquifer is thin where these rocks are near to the surface. In the area around the REFINERY the impermeable sediments are covered by the great thickness of the White Limestone (Newport Formation) and they do not affect the depth to which water can penetrate. The depth of solution in the limestone is limited by the lowest base level in effect during the history of solution development. The degree of karstification has a direct bearing on the capacity of the limestone to store and transport water. In the area beneath the REFINERY the level of karstification and high permeability in the limestone was found to be over 100 metres deep and has been proven to be over 150 metres deep within the central depression.

The reservoir volume is assumed to be equivalent to the saturated thickness of the reservoir. Assuming a saturated thickness of at least 100 metres and an area of the aquifer bounded by the South Coastal Fault to the south, by the Rio Minho to the west, by the fault between the plant and the Brazilletto Mountains to the east and by an imaginary east-west line drawn north of the Great House and Sam Wint wells with an approximate area of 34.5 square kilometres, the volume of the reservoir would be 345 million cubic metres of water (a value of 10% is used for the calculation of the reservoir volume).

The groundwater table elevations are relatively flat in the central area of the basin and around the REFINERY. They are controlled by several factors, which will include the storativity and the transmissivity of the aquifer. The dry season water table elevation varies from 2.5 metres above sea level to a high of 5 metres above sea level, which gives an average water table elevation of approximately 3.75 metres above sea level within the study area. The total water that could be abstracted is 12.94 MCM.

3.3.4 WATER QUALITY

3.3.4.1 AMBIENT WATER QUALITY

The groundwater resources of the Clarendon Plains and the area around the REFINERY are associated with the limestone aquifer, which occurs throughout the area and fills the central depression. Except where contaminated by industrial and municipal effluents or seawater, the quality of the groundwater is generally as follows:

- pH 7.2
- Conductivity 450 to 700 uS
- TDS 250 to 450 mg/l
- Coliform 5 MPN/100 ml.

Total Dissolved Solids (TDS) tends to be slightly high for use in industrial boilers without softening, but the bacteriological quality requires minimum treatment for use as a municipal/ public or private water supply. However where contamination has occurred the quality would vary depending on the nature of the contaminant.

The typical background quality of the groundwater in the limestone aquifer is shown in Table 3-7 below.

TABLE 3-7: TYPICAL BACKGROUND QUALITY OF GROUNDWATER IN THE LIMESTONE AQUIFER-CLARENDON

Constituents	Units	Concentrations
pH		7.2
Turbidity	NTU	<1.0
Colour	HU	<5
Specific Conductivity	uS	550
Calcium	mg/l	<75

Constituents	Units	Concentrations
Magnesium	mg/l	10
Sodium	mg/l	12
Potassium	mg/l	1.0
Iron	mg/l	0.01
Chloride	mg/l	10
Sulphate	mg/l	8
Nitrate	mg/l	4
Carbonate	mg/l	0.0
Bicarbonate	mg/l	260
Total Hardness	mg/l	270
Total Alkalinity	mg/l	260
Total Dissolved Solids	mg/l	350
Bacteriological	MPN/100 ml	<5
Na:Cl ratio		<1.5

3.3.4.2 GROUNDWATER CHEMICAL TYPES

All groundwater can be classified into types according to the dominance of various anions and cations in the water. The major types are:

1 Calcium/Magnesium bicarbonate

2 Sodium bicarbonate

3 Calcium chloride

4 Sodium chloride

Natural groundwater, which is uncontaminated, has as the dominant cation, calcium or magnesium, dependent on the source rock through and over which the water flows. The dominant anion is bicarbonate and together with the dominant cation, the chemical water type becomes calcium or magnesium bicarbonate water. The changes from the naturally occurring calcium bicarbonate type water to the sodium chloride type water is an indication of contamination of the groundwater and the replacement of the calcium by sodium and the bicarbonate by chloride.

Around the REFINERY the major groundwater chemical type is the calcium bicarbonate type with sodium chloride type to the south around Hayes Common-Raymonds and at depth within the limestone aquifer.

3.3.4.3 SOURCES OF GROUNDWATER CONTAMINATION

The assessment of any change in groundwater quality and type must include an evaluation of the possible sources of contamination and the impact each can have on water quality.

Around the REFINERY there are three main possible sources of contamination of groundwater. These are:

1 The intrusion of saltwater (saline intrusion) into the karstic aquifer as a result of the **over pumping** resulting in high chloride and sodium concentrations.

2 **Industrialization**, specifically the bauxite/alumina operations at Halse Hall consisting of the plant and the RDAs.

3 **Municipal** impacts from the improper disposal of liquid and solid wastes.

3.3.4.3.1 SALTWATER INTRUSION

The limestone formation responds as a Ghyben-Herzberg aquifer. The Ghyben-Herzberg Principle specifies that the occurrence of saline groundwater in a coastal aquifer, similar to that of the Rio Minho Hydrologic basin within which the REFINERY is located, is dependent on the head of fresh water above sea level. A ratio if 1:40 i.e. one metre of fresh groundwater above sea level to 40 metres of fresh groundwater below sea level before entering the freshwater/saline water interface. This has been proven by Botbol in the adjoining Rio Cobre Hydrologic basin a karstic limestone area. Around the REFINERY with water levels 6 metres above sea level there should be 240 metres of freshwater below sea level before the fresh/salt water interface is encountered.

Within the area of the REFINERY the potential for saline intrusion by way of upconing from the Ghyben–Herzberg Zone is provided by the below sea level pumping depressions associated with the well fields around the Hayes Common-Raymonds area. The saline water can also be brought to the upper level of the aquifer by way of the faults, which act as preferred paths of flow due to the increased permeability along the fault zones. In addition the wells south of the REFINERY are all located along the South Coastal Fault Zone, which is open to the sea at both its eastern and western ends.

3.3.4.3.2 INDUSTRIALIZATION-BAUXITE/ALUMINA OPERATIONS

The bauxite/alumina industry produces an alkaline waste known commonly as "red mud". This bauxite residue is a thick fluid suspension with water content between 65 – 75% depending on the technology and method of management used, high concentrations of sodium and hydroxide ions; iron oxides and organic substances which originate from the bauxite and which on decomposition and reaction with caustic soda, impart an unpleasant smell to the water. The pollutants present in the bauxite residue are in sufficient quantities to make the groundwater unfit for domestic and agricultural uses, in the event the bauxite residue is not effectively contained within the storage areas. Effective containment is achieved through the use of sealants such as clay.

The REFINERY was constructed in the early 1970's. The plant is located on the Clarendon Plains an important agricultural region where over 90% of the irrigation water and 100% of the public water supply is derived from groundwater using wells tapping the limestone aquifer. The bauxite residue is a potential agent for degrading this water quality with potentially significant social and economic consequences.

The bauxite residue is disposed of into Residue Disposal Areas (RDA). RDA 1 was commissioned into use on March 6, 1972. RDA 2 and RDA 3 were constructed in 1980 and 1990 respectively. RDA 4 was constructed in 2000 and the dike was raised by an additional 20 feet in 2004. The RDAs have all been sealed with clay in the base and the sides. Supernatant (caustic enriched) liquor and plant runoff are collected and stored in RDAs (clear and storm lakes) from where it is recycled into the plant. Total volume of mud in storage exceeds 15 million tonnes.

3.3.4.4 CONTAMINATION CRITERIA

The monitoring programmes established by Jamalco in conjunction with the Government of Jamaica regulating agencies are intended to detect above average concentrations of the chemical constituents that can contaminate the groundwater. The inclusion of the aesthetic indices such as colour, taste and odour also assist in the determination of the level of contamination of groundwater.

Five indices are specifically used to detect contamination from the bauxite/alumina operations. These are:

Sodium to chloride concentration ratio exceeding the maximum ratio encountered in uncontaminated groundwater in Jamaica of 1.5 (White and Rose 1975).

1 High sodium content. This alone is not a precise indicator as sodium chloride waters are found in the limestone aquifer as a result of saline intrusion. However in this form of contamination high sodium concentrations are associated with high chloride concentrations. This is not the case in the event of a caustic contamination.

2 Sodium to calcium concentration ratio in excess of the ratios generally encountered in uncontaminated groundwater of 1.0

3 High pH values in excess of 8.5 units, the limit set by the USEPA and the WHO for drinking water and the maximum encountered in groundwater in Jamaica.

4 The presence of suspended solids, red discoloration, poor smell and unpleasant taste.

In addition high conductivity, TDS and alkalinity concentrations aree used to determine the source of the contamination.

3.3.4.4.1 WATER QUALITY MONITORING

Jamalco has conducted water quality monitoring around the REFINERY since 1989. The programmes have been intensified over the years to generate information on the impact of the bauxite/alumina operations on the groundwater quality of the limestone aquifer. Initially the programme consisted of monthly sampling and analysis of existing production wells within and around the REFINERY. The drilling of the monitoring wells has led to the expansion of the monitoring programmes and the level of the analysis done. The monitoring and analysis has led to an increased database on which to base the evaluation of the impacts of the bauxite/alumina operations on groundwater quality. To date the following have been completed and for which data is available:

1 Analysis on a monthly basis of production wells between January 1998 to the present for the parameters- pH, conductivity, chloride, sulphate, sodium, magnesium carbonate, calcium carbonate, and hardness. The sodium:chloride

ratio was calculated from the results. The sampling points included-Production wells 1 and 2, Hayes Common wells 1,2 and 3, Dry River 2 and 5 wells, Hayes Public well, Quaminus 2 well, Halse Hall well (Greenvale), Woodside well, Breadnut Valley well, Rocky Point (Morelands) well, Rocky Point drinking water (trucked water) and Webbers Gully.

2 The completion of the first 8 monitor wells in 1994 led to the expansion of the programme and provided monitor points that were not affected by pumping and tapped groundwater deep within the aquifer.

3 The completion of the next 4 monitor wells in 1997 further expanded the programme.

4 During the drilling of the monitor wells water samples were collected every 30 metres depth below the water table to ensure that a water quality profile of the monitor well could be developed. Each monitor well yielded 4 sets of samples. The parameters analyzed are shown in Table 3-8 below.

5 Since 1998 Jamalco has contracted a consultant to carry out quarterly sampling and analysis of all the wells as an independent assessment of the impacts of the bauxite/alumina operations on water quality. The samples are analyzed by a USEPA and NELAP certified laboratory in the USA. The sample points and the parameters analyzed are shown in Table 3-9. Jamalco at the same time continues its independent sampling and analysis of the same monitor points.

6 In 2000 Jamalco instituted a twice-yearly sampling of all the sources of water to its facilities to assess the quality of water being used for domestic purposes. The sampling points and the parameters analyzed are shown in TABLE 3-10 below.

The data collected has been analyzed and to date no significant contamination of groundwater has been detected.

TABLE 3-8: Parameters Analyzed for each Water Sample, MW1 to 12.

Group of Parameters	Constituents
Metals	Aluminium: Arsenic: Barium: Cadmium: Calcium: Chromium: Iron: Lead: Magnesium: Manganese: Mercury: Selenium: Silver: Sodium.
Inorganics	Cyanide (Total): Chloride: Carbonates: Bicarbonates: Nitrate: Sulphate: Hexavalent Chromium.
Physical/chemical	Turbidity: pH: Specific Conductance
Organics	Phenol: Polychlorinated Biphenyls (PCB): Naphthalene
VOAs (Volatile Organic Aromatic Compounds)	Acetone: Benzene: toluene: Carbon Tetrachloride: Vinyl Chloride: Chloroform: Chlorobenzene: 1,1-Dichloroethane: Methyl Ethyl Ketone (2-Butane)
TPH (Total Petroleum Hydrocarbons)	Hydrocarbons-Petroleum

TABLE 3-9: List of Wells and Parameters-Monthly Sampling Programme Jamalco

Sampling Point	Well Depth (m)	Use of Water	Parameters
Monitor Well 1	155.4	Monitoring	Lab:- Sodium
Monitor Well 2	155.4	Monitoring	Calcium,
Monitor Well 3	155.4	Monitoring	Magnesium
Monitor Well 4	155.4	Monitoring	Chloride
Monitor Well 5	155.4	Monitoring	Sulphate
Monitor Well 6	155.4	Monitoring	Nitrate
Monitor Well 8	155.4	Monitoring	TDS
Monitor Well 9	135.0	Monitoring	Alkalinity
Monitor Well 10	152.4	Monitoring	
Monitor Well 11	155.4	Monitoring	Field:- pH
New Bowens	70.1	Public Supply	Temp.
Dry River 3	76.2	Industrial	Cond.
Dry River 4	55.8	Irrigation	
Hayes Public	67.0	Public Supply	Water Levels
Production 1	86.3	Industrial	Na:Cl ratio
Production 2	122.0	Industrial	calculated

Duplicate samples are collected and a comparison made of the analytical results between the Jamalco Laboratory and the USEPA Laboratory in the USA that analyses the samples. The comparison indicates that on the whole the results compare favourably. However at times the difference in the chloride concentration has been very large. This probably due to the fact that the samples are analyzed beyond the maximum holding time and the samples were not preserved in the field.

TABLE 3-10: LIST OF FACILITIES, SOURCES, SAMPLE SITES AND PARAMETERS ANALYZED

Facility/Location	Source/Supply	Sample Site	Parameters
Clarendon Alumina Works [REFINERY]	Production Well 1	At Well Head	**Metals:** Aluminium; Arsenic: Cadmium: Calcium: Copper: Iron: Lead: Magnesium; Manganese: Mercury: Selenium: Sodium: Zinc **Non-metals:** Chloride; Cyanide: Fluoride; Nitrate: Sulphate: TDS: pH; Temp.: **Bacteria:** Coliform -T and F **Pesticides:** gamma-BHC: Aldrin: Dieldrin: 4,4'-DDT: Technical Chlordane: Methoxychlor. **Organics:** 1,1-Dichloroethane: Chloroform: Benzene: 1,2-Dichloroethane: 2,4,6-Trichlorophenol: Pentachlorophenol: Hexachloroethane: Benzo(a)Pyrene.
	Production Well 2	At Well Head	
	Dry River Well 3	At Well Head	
	Groundwater from PW 1/PW 2 after Treatment	Drinking Fountain in Building 1	
Halse Hall Great House	Great House Well	At Well Head	
	Great House Well after Treatment	At Great House Kitchen Tap	
Breadnut Valley	Breadnut Valley Well	At Well Head	
	Breadnut Valley Well after Treatment	Drinking Fountain in Plant Office	
Woodside Lands Office	NWC Supply from Kraal Well 1	Drinking Fountain in Main Office	
Rocky Point Port	Trucked Water	Domestic Tank Tap	
Waterloo Road Office	NWC Supply from Hermitage Dam	Tap in Office Kitchen/Pantry	

3.3.4.4.2 ANALYTICAL RESULTS

a) Borehole Profile

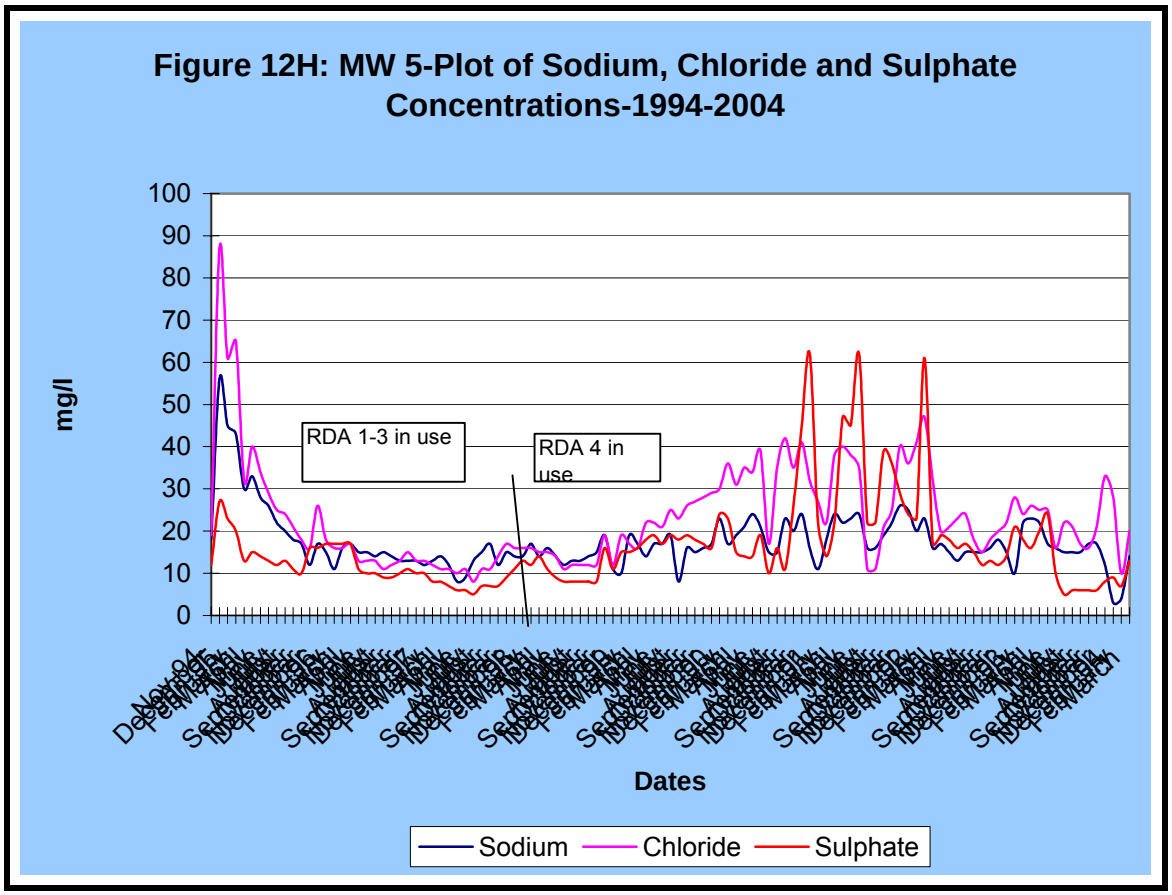
The samples collected from each borehole at 30 metre intervals during drilling indicate that no contamination resulting from the bauxite/alumina operations was detected in any of the wells. In several wells the sodium concentration was higher than normal but so was the chloride concentration. The Na:Cl ratios were at all times less than 1. It is noteworthy that neither Arsenic, Cadmium, Mercury, Selenium nor Silver was detected at any depth within any of the wells. Phenol was the only organic compound detected at one level in 5 of the wells and all at very low concentrations. No Volatile Aromatic Compound was detected at any concentration that exceeded the guideline values. No TPH was detected that would be a cause for concern.

b) Monthly Sampling and Analysis

The results for the monthly sampling and analysis programme are shown plotted for four of the monitoring points-3 monitor wells and 1 production well. The points are MW 5 to the west of the RDAs; MW 9 to the east of the RDAs; MW 10 to the south of the RDAs

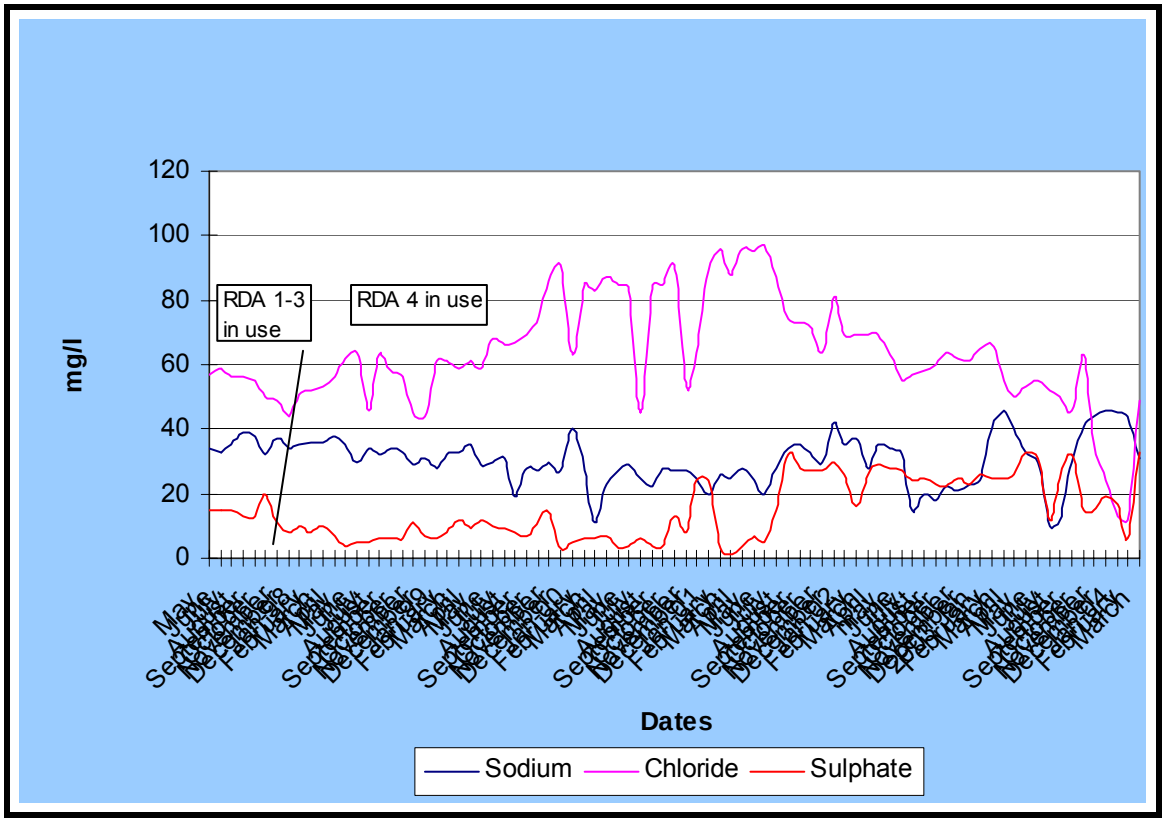
and Hayes Public well located to the south of the RDAs and between MW 9 and MW 10. The Hayes Public well was selected, as this well is the source of the water supply for the Hayes community and has been the discussion of many community meetings as to its quality and suitability for domestic uses. The plots of the sodium, chloride and sulphate concentrations are shown as figures Figure 3-15 to Figure 3-19.

FIGURE 3-15: MW 5-Plot of Sodium, Chloride and Sulphate Concentrations-1994-2004



At MW 5, to the west of the RDAs, the data plot Figure 3-15 shows no significant increase in the sodium concentration over time. There is a close correlation between the chloride and sodium concentrations. In all cases the Na:Cl ratio would be less than 1. The assessment took into consideration the impact of each RDA as it was commissioned into service. As can be seen there was an increase in the chloride and sodium concentration after RDA was brought on stream. However, this is not due to leakage from the RDA but to the below average recharge coupled with increased pumping.

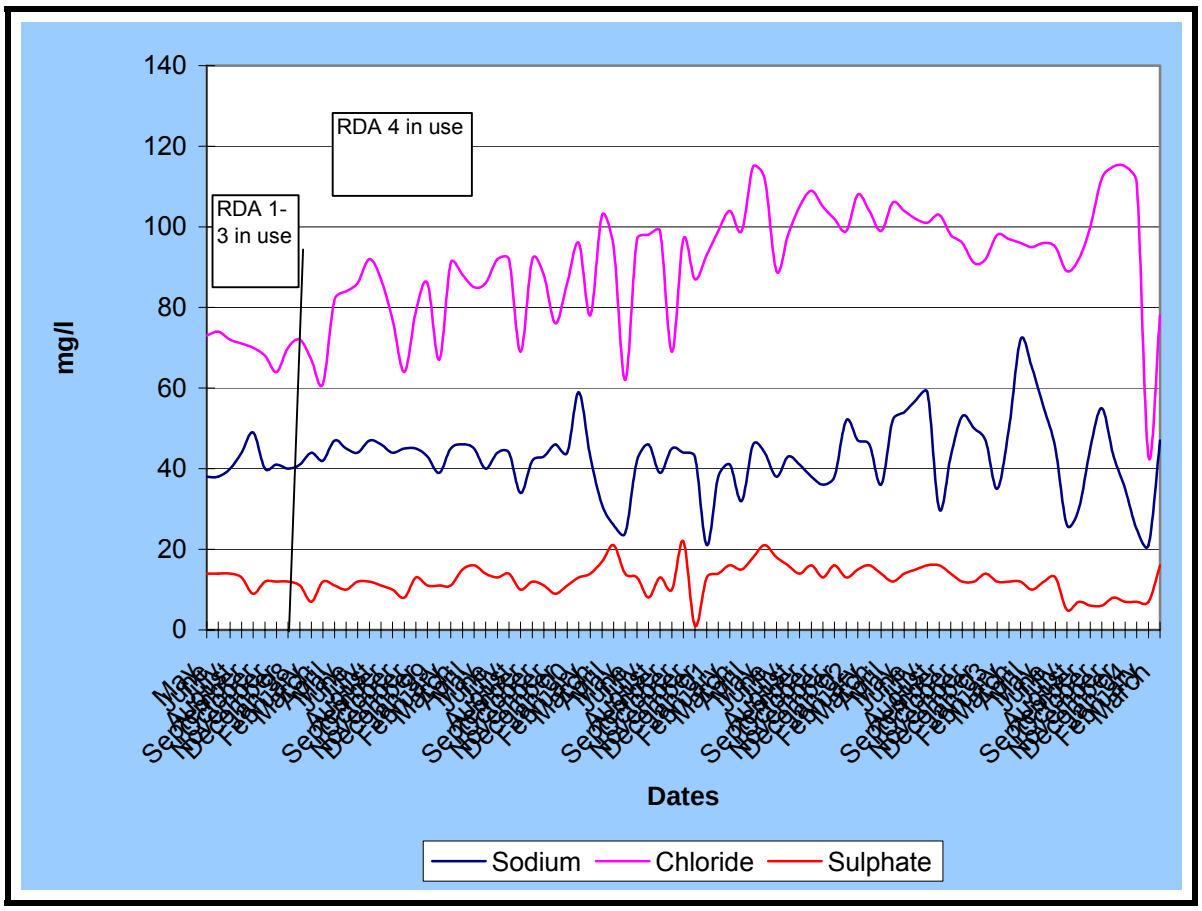
FIGURE 3-16: MW 9-Plot of Sodium, Chloride and Sulphate Concentrations-1994-2004



At MW 9, to the east of the RDAs, the plot Figure 3-16 while showing a varying concentration for sodium does not show a trend toward an increasing concentration. The chloride shows an increasing upward trend in concentration up to June 2001 where after there is a decline in the concentration. This increased chloride concentration is probably due to the less than average rainfall/recharge between 1999 to 2000 and the increased pumping to meet water demand. Here also the high chloride concentration compared to the lower sodium concentration would ensure that the Na:Cl ratio is less than 1.

The commissioning of RDA 4 did not lead to any increase in sodium concentration. The increase in chloride concentration is not attributable to the RDA but to recharge and pumping conditions and would most probably represent increased salinity of the groundwater during that period. An increase in the sulphate concentration after June 2001 was noted. This led to the concentration moving from less than 20 mg/l to between 20 to 30 mg/l. The reason for this is not known but the concentration is still far below the WHO guideline value of 400 mg/l.

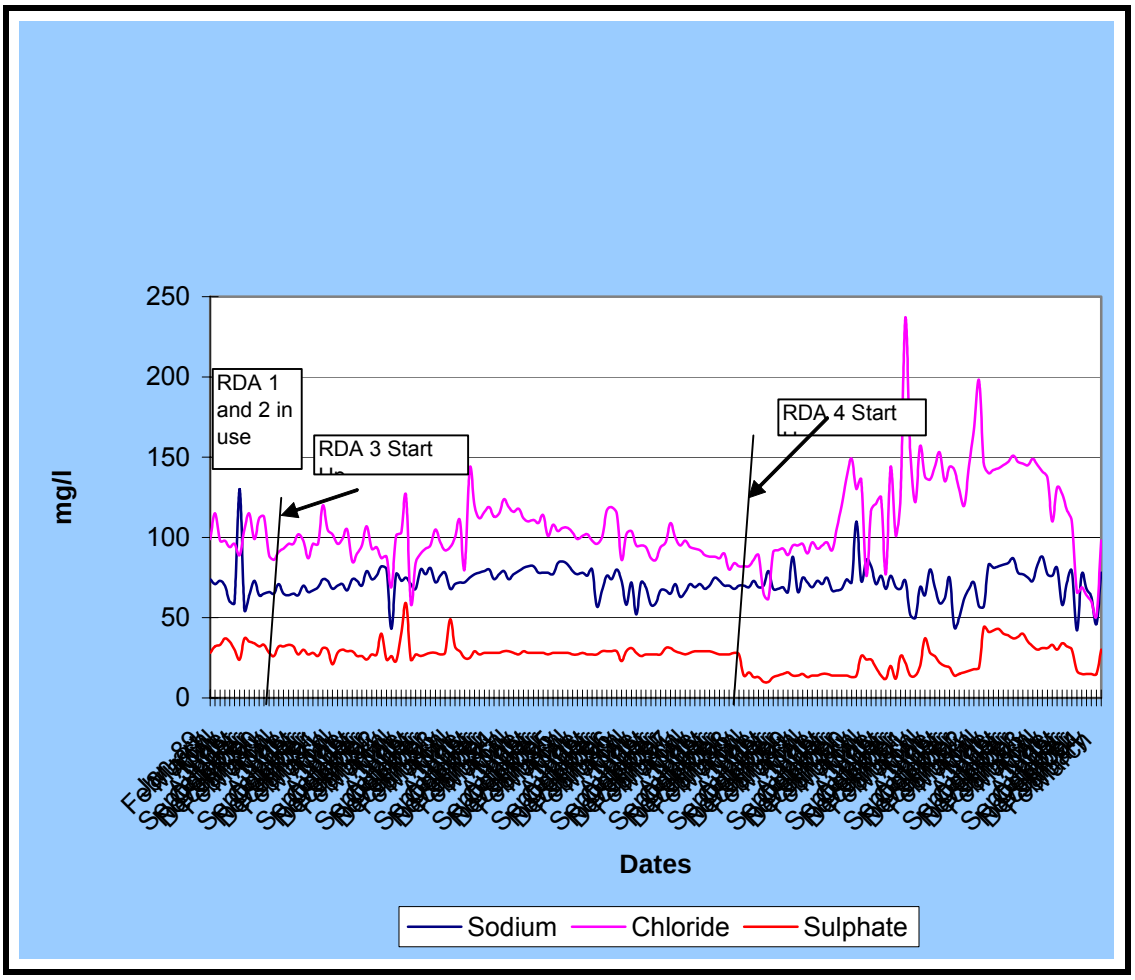
FIGURE 3-17: MW10-Plot of Sodium, Chloride and Sulphate Concentrations-1994-2004



At MW 10, to the south of the RDAs, the plot (Figure 3-17) there is a trend to an increase in chloride concentration. This well is located close to the Dry River 4 irrigation well that has reported chloride concentrations of up to 150 mg/l. There has not been a trend towards an increase in the sodium and sulphate concentrations.

The use of RDA 4 after 1998 has not resulted in an increase in the sodium concentration. As is the pattern with the other wells an increase in the chloride concentration was noted. However this is more related to salinity changes within the aquifer. There was no overall change in the sulphate concentration.

FIGURE 3-18:Hayes Public Well Plot of Sodium, Chloride and Sulphate Concentrations 1989-2004



At the Hayes Public well, also south of the RDAs, the plot Figure 3-18 shows a very constant concentration of sodium and chloride up to the year 2000. The chloride concentration has shown an increase since 2000 that again may be due to the below average recharge and increased pumping. The start up of RDA 3 and RDA 4 as shown on the graph did not in any way affect the concentrations of sodium and sulphate. This well is the most southern of the monitor points and is the closest to the South Coastal Fault and the wells at Hayes Common that show high chloride

concentrations exceeding 350 mg/l at times. The Na:Cl ratio here would also be less than 1.

The controversy of the possible contamination of the Hayes Public well has led to many meetings between Jamalco and the Hayes community. The monthly sampling does not show any caustic contamination at the Hayes well. Further investigation was recommended and on April 1, 2004 a sample was collected and analyzed for heavy metals. The results are presented below in Table 3-11.

As can be seen only one parameter exceeds the World Health Organization (WHO) guideline value for drinking water. That parameter is Aluminium and the concentration was reported at 0.22 mg/l while the guideline value is 0.20 mg/l. Aluminium has no toxicological effect on the human body. The concentration of Copper was reported at 0.011 mg/l with a guideline value of 1.0 mg/l. Barium was reported at 0.055 mg/l. There is no guideline value for Barium. All the other thirteen parameters had concentrations less than the Laboratory Reporting Limit (LRL).

The conclusion reached is that the water quality at the Hayes Public well meets the drinking water guidelines and is suitable for use as a domestic water supply. The bauxite/alumina operations have not impacted on the water quality in the limestone aquifer to affect that being abstracted at the Hayes Public well.

TABLE 3-11: Analytical Results of Heavy Metals for Hayes Public Well (NWC) – April 2004

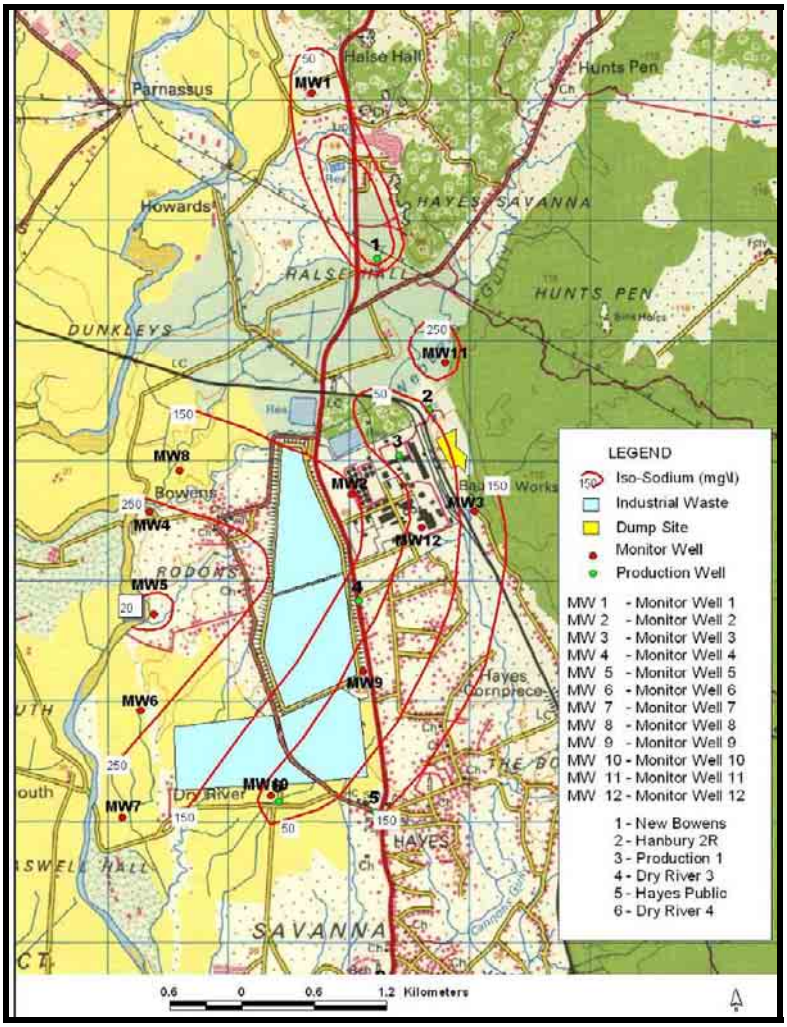
Parameter	Concentration (mg/l)	Lab Reporting Limit (LRL) (mg/l)	WHO Guideline Limit for Drinking Water (mg/l)	Remarks
Aluminium	0.22	0.10	0.20	Exceeds Guideline-No toxicological Effect.
Antimony	<0.50	0.50	0.002	
Arsenic	<0.50	0.50	0.05	
Barium	0.055	0.010	None	
Beryllium	<0.0050	0.0050	None	
Cadmium	<0.010	0.010	0.005	
Chromium	<0.020	0.020	0.05	
Copper	0.011	0.010	1.0	
Iron	<0.10	0.10	0.3	

Parameter	Concentration (mg/l)	Lab Reporting Limit (LRL) (mg/l)	WHO Guideline Limit for Drinking Water (mg/l)	Remarks
Lead	<0.10	0.10	0.05	
Manganese	<0.010	0.010	0.1	
Mercury	<0.00020	0.00020	0.001	
Nickel	<0.020	0.020	None	
Selenium	<0.50	0.50	0.01	
Thallium	<0.50	0.50	0.006	
Zinc	<0.020	0.020	5.0	

The analytical results for the quarterly sampling done in April 2004 are included as Figure 3-11 and Table 3-13 The sodium concentration reported for monitor well 1 and shown in Figure 3-11 incorrect and is not in keeping with previous historical results reported. This high sodium concentration and the lower chloride concentration yields a Na:Cl ratio of 2.73 which would indicate caustic contamination. However this well is located north and upgradient of the REFINERY. It is outside the zone of contamination from the bauxite/alumina works and saline intrusion. The duplicate sample analyzed by Jamalco reported a sodium concentration of 8 mg/l and chloride concentration of 12 mg/l with the Na:Cl ratio at 0.67 which is more in keeping with the historical results reported since 1994.

The iso-sodium plot for April 2004 is shown as Figure 3-19. Sodium concentration varies from 50 mg/l to over 250 mg/l west of the RDAs. The contours of the highest sodium concentrations (250 mg/l) match those areas where saline intrusion is met at depth in the wells-MW 6 and 8.

FIGURE 3-19: Iso-Sodium Plot - April 2004



c) Facilities Sampling

The sampling of sources of water being supplied to Jamalco's facilities across Clarendon and the Kingston Office is executed twice per year-once in the dry season and once in the wet season. The objective of the sampling programme is to determine the quality of water supplied for use within the facility and to determine the impact of the bauxite/alumina operations on water quality. As shown in Table 3-10 the facilities are supplied with water from both Jamalco's own wells and from the National Water Commission's public supply. The analysis is for specific parameters and covers metals, non-metals, pesticides, PCBs and volatile organics. The results for January 2004, the last sample period, are presented as Table 3-14 to Table 3-17. The results indicate that the bauxite/alumina operations, the disused solid waste dump at Mineral Heights and the sewage disposal methods in the May Pan area have not impacted on the water quality in the limestone aquifer.

TABLE 3-12: Summary of Analytical Results and Field Data – April 2004

PARAMETER	MONITORING WELL RESULTS(mg/l)											WHO DW Guideline (mg/l)	US EPA DW Standard (mg/l)	Typical Limestone Aquifer *WQ (mg/l)
	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-8	MW-9	MW-10	MW-11	MW-12			
LAB RESULTS														
CALCIUM	72	74	NO	78	66	110	80	63	60	170	N	75		75
MAGNESIUM	33	41		53	12	44	46	37	37	22	O	150		10
SODIUM	71	180	S	250	17	280	170	31	47	290		200	200	12
CHLORIDE	26	350	A	430	20	470	360	49	78	410	S	250	250	10
NA/CL RATIO	2.73	0.51	M	0.58	0.85	0.60	0.47	0.63	0.60	0.71	A	-	-	<1.5
ALKALINITY	260	250	P	250	210	310	260	280	270	510	M	-	-	260
**NITRATE	0.24	0.13	L	<0.050	0.073	1.00	0.17	0.069	0.12	0.18	P	10 (as N)	10 (as N)	4
SULFATE	19	23	E	60	13	58	38	33	16	63	L	400	250	8
TDS	340	850	HOLE	1100	290	1300	880	390	430	1300	E	-	500	350
Field Data														
TEMP. (*C)	29.2	29.8	Blocked	33.1	31.7	30.6	31.0	28.9	28.8	25.1		-	-	
pH	7.46	7.71	At 144'	7.51	7.53	7.29	7.48	7.52	7.53	7.44		6.5-8.5	6.5-8.5	7.2
COND. (uS)	569	1430		1930	500	2050	1460	681	742	2150		-	-	550
DTW (m)	51.46	43.71	42.43	35.54	32.93	32.26	34.95	38.10	33.38	47.91				
DOW (m)	152.4	155.4	155.4	155.4	155.4	152.4	155.4	135.00	152.4	155.4	143.2			
TOW ELEV. (m)	56.66	49.34	47.66	40.49	37.90	36.77	39.92	42.90	38.19	53.25	50.24			
WATER(m)(amsl)	5.20	5.63	5.23	4.95	4.97	4.51	4.97	4.80	4.81	5.34				
ODOUR/OTHER										**Very Turbid**				

***Shaded Values = exceedances *WQ – Water Quality. NS – Not Sampled. **Nitrate – As N includes Nitrite if present. ND – Not Detected NP – Well Not**

TABLE 3-13: Summary of Analytical Results and Field Data – April 2004

PARAMETER	MONITORING WELL RESULTS (mg/l)											WHO DW Guidelines (mg/l)	US EPA DW Standards (mg/l)	Typical Limestone Aquifer WQ(mg/l)
	PW-1	PW-2	HP	NB	DR-3	DR-4								
LAB RESULTS														
CALCIUM	88	88	98	77	P	100						75		75
MAGNESIUM	14	16	20	11	U	23						150		10
SODIUM	42	43	78	22	M	87						200	200	12
CHLORIDE	52	70	98	31	P	140						250	250	10
NA/CL RATIO	0.81	0.61	0.80	0.71		0.62						-	-	<1.5
ALKALINITY	270	260	310	240	O	330						-	-	260
**NITRATE	2.2	2.1	1.5	1.9	U	1.3						10 (as N)	10 (as N)	4
SULFATE	15	15	30	5.4	T	34						400	250	8
TDS	410	380	560	320		610						-	500	350
Field Data														
TEMP. (*C)	24.6	25.4	26.1	24.5		25.8						-	-	
pH	7.74	7.71	7.44	7.63		7.53						6.5-8.5	6.5-8.5	7.2
COND. (uS)	659	700	900	481		969						-	-	550
DTW (m)	ND	ND	ND	ND	ND	ND								
DOW (m)	86.3	122	67.0	70.1	76.2	55.8								
TOW ELEV. (m)														
WATER(m)(amsl)														

***Shaded Values = exceedances *WQ – Water Quality. NS – Not Sampled. **Nitrate – As N includes Nitrite if present. ND – Not Detected NP – Well Not Pumping.**

TABLE 3-14: Analytical Results-Metals-January 2004

PARAMETERS	MONITORING POINTS RESULTS (mg/l)											LRL* (mg/l)	WHO DW Stds (mg/l)	US EPA DW Stds. (mg/l)
	Production Well 1	Production Well 2	Buildg 1 Ftn.	Plant Stores Ftn	Great House Well	Great House Tap	WS Tap	BV-Well	BV-Tap	RP Tap	WR Tap			
METALS														
Aluminium	0.24	0.23	0.22	0.23	0.21	No	0.20	0.26	0.24	0.20	0.29	0.1	0.2	None
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.05	0.03
Cadmium	<0.0005	<0.0005	0.00072	<0.0005	<0.0005	Data	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0005	0.005	0.005
Calcium	91	91	90	89	85		80	97	97	78	43	0.5	75	None
Copper	<0.002	0.0041	0.57	0.0064	<0.002	Sample	0.0097	0.0094	0.16	0.0066	<0.002	0.005	1.0	1.3
Iron	0.047	0.014	0.063	0.014	0.010		0.034	0.18	0.020	0.036	0.012	0.1	0.3	0.3
Lead	<0.005	<0.005	<0.005	<0.005	<0.005	Bottle	<0.005	<0.005	<0.005	<0.005	<0.005	0.002	0.05	0
Magnesium	15	15	15	15	12		9.3	1.4	1.4	15	10	0.1	150	None
Manganese	< 0.005	<0.005	<0.005	0.018	<0.005	Broke	<0.005	<0.005	<0.005	<0.005	0.008	0.005	0.1	0.05
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0002	0.001	0.002
Selenium	0.006	<0.005	<0.005	<0.005	<0.005	Spilt	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.01	0.05
Sodium	48	48	48	48	21		7.2	5.8	5.6	48	10	0.5	200	200
Zinc	0.099	<0.020	0.13	2.2	<0.020	Sample	2.1	0.038	0.026	<0.020	<0.020	0.02	5.0	5.0

NOTES
Production Well 1-At well head ***LRL-**
Laboratory Reporting Limit
Production Well 2-At well head
Plant Stores-At Drinking Water Fountain
Buildg 1 Ftn - Building 1 Drinking Water Fountain.
Great House Well - At Well Head.
Great House Tap – Kitchen Tap.
WS Tap - Woodside Drinking Water Fountain (NWC Supply).
BV Well – Breadnut Valley Well – At Well Head.
BV Tap – Breadnut Valley Drinking Water Fountain.
RP Tap – Rocky Point Port Drinking Water Tank-At Tap (Trucked Water).

TABLE 3-15: Analytical Results-Non-Metals and Bacteriological-January 2004

PARAMETERS	MONITORING POINTS RESULTS (mg/l)											LRL* (mg/l)	WHO DW Stds. (mg/l)	US EPA DW Stds. (mg/l)
	Production well 1	Production well 2	Buildg 1 Ftn	Plant Stores Ftn	Great House Well	Great House Tap	WS Tap	BV-Well	BV-Tap	RP Tap	WR Tap			
NON-METALS														
Chloride	56	58	58	57	27	27	10	13	12	61	10	1	250	250
Cyanide	0.0033	<0.001	<0.001	<0.001	0.0014	<0.001	0.0012	0.0011	0.0026	0.003	0.0048	0.001	0.1	0.1
Fluoride	0.16	0.13	0.13	<0.10	<0.10	0.14	0.14	<0.10	<0.10	0.12	0.10	0.1	1.5	4
Nitrate*	2.4	2.6	2.7	2.2	2.4	2.4	1.7	1.5	1.5	2.4	0.23	0.05	10	10
Sulphate	22	23	21	22	6.9	6.5	3.5	2.4	2.5	23	39	2	400	250
Total Dissolved Solids (TDS)	430	430	420	430	310	320	270	270	260	390	210	10	1000	500
PH	7.44	7.57	7.77	7.42	7.58	7.78	7.44	7.44	7.45	7.77	8.01	NA	6.5-8.5	6.5-8.5
Temperature	24	24.5	10.5	13.4	25.3	26.1	29.3	30.1	18.8	28.6	25.4	NA	None	None
BACTERIOLOGICAL (MPN/100ml)														
Total Coli form	< 3	< 3	<3	<3	< 3	<3	<3	<3	< 3	<3	< 3	NA	0	0
Faecal Coliform	< 3	< 3	< 3	<3	< 3	<3	<3	< 3	< 3	< 3	< 3	NA	0	0

NOTES

Production Well 1-At well head.

Production Well 2-At well head .

Plant Stores-At Drinking Water Fountain

Buildg 1 Ftn - Building 1 Drinking Water Fountain.

Great House Well - At Well Head.

Great House Tap –Kitchen Tap.

WS Tap - Woodside Drinking Water Fountain (NWC Supply).

BV Well – Breadnut Valley Well – At Well Head.

BV Tap – Breadnut Valley Drinking Water Fountain.

RP Tap – Rocky Point Port Drinking Water Tank-At Tap (Trucked Water).

WR Tap – Waterloo Road Office Kitchen Tap (NWC Supply).

***LRL-Laboratory Reporting Limit**

***Nitrate-Nitrogen**

TABLE 3-16: Analytical Results-Pesticides/PCBs-January 2004

PARAMETERS	MONITORING POINTS RESULTS (ppb)											LRL* (ppb)	WHO DW Stds (ppb)	US EPA DW Stds. (ppb)
	Production well 1	Production well 2	Buildg 1 Ftn	Plant Stores Ftn	Great House Well	Great House Tap	WS Tap	BV-Well	BV-Tap	RP Tap	WR Tap			
PESTICIDES /PCBs														
gamma-BHC [Lindane]	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	3	0.2
Aldrin	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.03	NF
Dieldrin	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.03	NF
4, 4'-DDT	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.3	1	NF
Technical Chlordane	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	0.3	2
Methoxychlor	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	30	40

*LRL-Laboratory Reporting Limit NF-None Found

TABLE 3-17: Analytical Results-Organics-January 2004

PARAMETERS	MONITORING POINTS RESULTS (ppb)											LRL* (ppb)	WHO DW Stds. (ppb)	US EPA DW Stds. (ppb)
	Production well 1	Production well 2	Buildg 1 Ftn	Plant Stores Ftn	Great House Well	Great House Tap	WS Tap	BV-Well	BV-Tap	RP Tap	WR Tap			
ORGANICS														
1, 1-Dichloroethane*	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5	NF	5
Chloroform*	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5	30	100
Benzene*	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5	NF	5
1, 2-Dichloroethane*	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5	10	NF
2,4,6-Trichlorophenol+	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	10	NF
Pentachlorophenol+	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	50	10	30
Hexachloroethane+	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	NF	NF
Benzo(a)Pyrene+	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	0.01	NF

***Volatile Organic Compounds---+Base Neutral/Acid Compounds:**

NR-Not Reported ***LRL-Laboratory Reporting Limit**

3.4 AIR QUALITY AND WEATHER

3.4.1 AIR QUALITY

3.4.1.1 AIR QUALITY MANAGEMENT PROGRAM

Jamalco has developed and maintained an Air Emissions Management Program to ensure compliance with the Natural Resources Conservation Authority (NRCA) ambient air quality standards, pending air quality regulations, Alcoa Air Emissions standards as well as to conform with ISO 14001 requirements and the company's EHS policy.

The refinery which is the major source for atmospheric emissions is approximately 165 feet above mean sea level (amsl) and is surrounded by a mix of undeveloped and residential land uses. The terrain elevations rise up to over 400 feet amsl at approximately 2000 feet to the east of the refinery. The RDAs are not significant sources of air emissions.

3.4.1.1.1 METEOROLOGICAL FEATURES

The facility operates an on-site meteorological tower, which is located at the center of the refinery. Hourly surface observations are monitored which includes:

- Wind speed
- Wind direction
- Air temperature
- Barometric Pressure
- Ground temperature
- Precipitation and,
- Standard deviation of the Wind direction.

Analysis of data derived from the onsite tower indicates that predominantly there is a strong occurrence of light winds from the northeast, which is typical for areas within this tropical latitude. See wind rose, which shows a joint frequency distribution based on the wind speed and direction for each hour of the year.

3.4.1.1.2 AIR EMISSIONS

The primary emissions that are released from the REFINERY refinery include particulates, NO_x, SO_2, CO, neglible quantities of VOCs and trace levels of metal.

3.4.1.1.2.1 Particulates

Emissions of particulates are released from the calciners, boilers and medical waste incinerator. In addition, particulates are intermittently released as a result of mining activities, windblown dust associated with bulk material handling, transportation and stocking of raw material (bauxite), intermediate product (hydrate) and the alumina product itself.

Particulate emissions have also been associated with the Residue Disposal Area (RDAs) should the surface of these lakes become dry.

Proven particulate control and dust suppression strategies have been employed at Jamalco facilities, which have significantly minimized particulate and fugitive dust emissions.

These include but not limited to the use of hooded conveyors, sprinkler systems, cyclones, bag houses and ESPs.

The location has implemented a number of fugitive emission control measures inclusive of the following:

- Controlling fugitive particulate emissions from storage piles through enclosures, covers or stabilization, minimizing the slope of the upwind face of piles where practicable. Confining as much pile activity as possible to the down wind side of piles.
- Limiting the size of loads to minimize loss of material to wind and spillage.
- Planting special wind breaks at critical points.
- Prompt removal of soil and other dust -forming debris from paved roads and scraping and compaction of unpaved roads to stabilize the road surface as often

as necessary to minimize re-entrainment of fugitive particulate matter from the road surface.

- Vegetating areas with grass.
- To the extent practicable restricting vehicular travel to established paved roads.
- Watering of unpaved roads and other unpaved open spaces as often as necessary to minimize re-entrainment of fugitive particulate matter from these surfaces. Drip irrigation is also practiced at the refinery.
- Maintaining good house keeping practices to minimize the accumulation of materials, which could become fugitive.

The major source of fugitive dust at Jamalco is from open areas (uncovered with grass or unpaved).

3.4.1.1.2.2 NOx Emissions

NOx emissions are not anticipated to be an issue during the implementation of the RDA project.

3.4.1.1.2.3 SO_2 and CO Emissions

Sulphur dioxide and carbon monoxide emissions are not anticipated to be an issue during the implementation of the RDA project.

3.4.1.1.2.4 Trace Metals

Trace Metals such as mercury are not anticipated to be an issue during the implementation of the RDA project.

3.4.1.1.2.5 Ambient Air Quality Monitoring

Jamalco operates two ambient air-monitoring stations located in the New Bowens and Corn Piece communities. These stations are capable of monitoring SO_2, NOx, COx and Ozone.

Data derived from these stations have consistently shown levels well below the Jamaican Ambient Air Quality standards.

Monthly monitoring reports are submitted to the regulatory agencies through the Jamaica Bauxite Institute (JBI), which have responsibility to conduct environmental monitoring of the Bauxite & Alumina Industry.

Calibration checks are conducted on the monitors on a scheduled basis and are done within applicable test methods and manufacturers specifications.

Jamalco also maintains a stringent TSP monitoring program. There are seven (7) permanent TSP monitoring stations; these are located in communities around the refinery, at the RDAs, Breadnut Valley and at the Rocky Point Port facility.

3.5 WEATHER

3.5.1 REGIONAL SETTING/SPHERE OF INFLUENCE

Jamalco's refinery which is proposed for upgrade is located in Halse Hall, Clarendon between the New Bowens settlement to the north, Cornpiece to the south, the Braziletto Mountains to the east and its red mud lakes to the west. The plant has been in its present location since 1972 and is the largest industrial facility in the general area.

Major settlements in the area of the plant include:

- Cornpiece
- Kemps Hill
- Savannah
- Hayes Newtown
- New Bowens
- Race Course
- Hayes
- Rocky Point
- Raymonds
- Lionel Town
- Halse Hall
- Alley

3.5.2 RDA REGIONAL CLIMATE

South Clarendon has a dry climate. With poor surface drainage and extremely permeable soils, the area is heavily dependent on catchment of rainfall and often suffers from drought.

3.5.3 RAINFALL

Rainfall totals for the southern Clarendon region are low when compared to that of the northern Manchester regions. Over the period 1983 – 2003 the area averaged 988.1 mm (38.9 inches) of rainfall with a monthly average of 83.1 mm (3.27 inches). The area experiences its wettest period during the months of May-June (90 – 163 mm) and August-November (89 – 154 mm).

This generally low rainfall is responsible for the aggressive and well maintained irrigation regime employed at the Jamalco refinery to manage the real potential for fugitive dust emissions.

TABLE 3-18: ANNUAL RAINFALL - INCHES. JAMALCO REFINERY

YEAR	Month												YEAR'S TOTAL	MONTHLY AVERAGE
	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.		
1983	0.44	6.68	0.40		2.54	6.48	0.06	6.36	1.42	5.29	2.01	0.16	31.84	2.89
1984	0.52	2.17	5.39	0.58	5.37	3.62	2.13	1.76	5.88	3.86	1.75	0.07	33.10	2.76
1985	0.14	-	-	-	-	-	-	2.45	1.86	8.62	7.74	1.12	21.93	1.83
1986	1.95	0.78	1.05	3.53	-	22.56	1.36	0.52	3.36	8.87	2.01	0.78	46.77	3.90
1987	1.86	0.28	0.16	6.90	6.48	1.31	1.70	3.04	1.46	17.38	5.52	3.10	49.19	4.10
1988	0.10	0.63	1.63	2.20	5.62	1.59	1.65	8.70	8.81	1.24	6.53	1.81	40.51	3.38
1989	2.99	1.60	3.01	0.74	4.64	1.40	0.21	1.61	7.15	0.98	1.22	0.36	25.91	2.16
1990	2.04	0.79	1.78	2.51	1.43	2.11	2.26	0.60	1.33	6.59	7.68	1.80	30.92	2.58
1991	0.39	0.26	1.58	1.46	7.52	0.37	1.66	1.67	2.36	2.24	3.37	0.37	23.25	1.94
1992	0.21	2.22	0.38	1.61	9.11	2.95	0.47	2.14	4.36	2.82	1.24	0.22	27.73	2.31
1993	3.60	3.54	4.62	7.89	27.45	0.75	1.82	0.75	4.76	0.68	3.59	7.27	66.72	5.56
1994	1.74	0.07	2.62	3.29	4.10	0.00	1.70	4.10	3.22	0.58	13.85	0.70	35.97	3.00
1995	2.75	0.80	2.31	5.09	6.19	3.05	1.13	13.08	8.32	17.70	0.87	1.83	63.12	5.26
1996	1.40	0.17	0.90	0.94	0.60	0.92	2.17	4.40	6.12	6.83	7.22	0.03	31.70	2.64
1997	1.03	0.89	1.26	1.36	0.85	7.88	0.33	0.64	5.70	6.47	3.14	2.15	31.70	2.64
1998	0.74	1.54	8.55	2.53	0.67	1.14	4.96	4.15	11.36	5.71	2.21	4.66	48.22	4.02
1999	0.87	3.10	6.93	0.93	2.43	3.67	2.96	1.75	13.63	11.73	8.87	1.99	58.86	4.91
2000	0.77	1.75	1.65	3.47	1.28	0.85	2.47	2.00	9.28	3.80	1.05	6.19	34.56	2.88
2001	1.75	0.35	0.49	1.48	6.14	0.09	1.73	0.55	2.31	5.30	8.55	5.78	34.52	2.88
2002	3.27	1.81	2.39	3.80	20.05	6.68	0.34	0.47	22.48	6.04	0.94	1.60	69.87	5.82
2003	1.31	0.91	1.97	3.00	14.72	3.46	1.08	12.64	2.28	3.30	1.46	1.11	47.24	3.94
2004	1.07	0.16	0.24	0.16	1.07								2.70	0.54

Review of temperature data collected at the Jamalco refinery meteorological station at the refinery for a period 1999 -2003, indicates that the maximum temperatures range from 34.5 deg. Celsius to 31 deg. Celsius and that the low temperatures range from 24 deg. Celsius to 18.9 degrees. The intense and prolonged heat of this typically xerophytic

environment combined with the low rainfall results in a dry and sometimes dusty environment, if no controls are in place.

Jamalco has a sprinkling and irrigation regime for exposed areas of the plant, which includes landscaping and irrigation of open spaces.

TABLE 3-19: TEMPERATURE - JAMALCO REFINERY

MONTHS	1999		2000		2001		2002		2003	
	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.	MIN.
JANUARY	31.6	21.1	31.1	19.7	31.0	23.0	31.5	20.5	31.5	21.0
FEBRUARY	31.1	19.9	31.5	18.9	31.7	23.0	32.2	20.0	32.0	21.1
MARCH	31.5	20.8	31.8	19.1	31.4	20.2	32.7	19.9	32.3	21.4
APRIL	31.8	21.4	32.1	20.9	32.2	21.1	32.9	20.7	32.9	22.1
MAY	32.6	23.0	32.2	22.3	32.6	21.8	31.8	21.6	32.4	22.1
JUNE	32.6	23.6	32.6	22.7	33.3	22.7	32.2	22.3	32.1	22.9
JULY	33.4	23.5	33.8	22.7	33.5	23.5	32.9	23.0	33.4	23.1
AUGUST	33.8	24.0	33.7	23.2	33.8	23.5	34.4	23.3	34.0	23.0
SEPTEMBER	33.3	23.0	33.4	23.0	34.5	23.0	33.3	22.8	34.0	22.8
OCTOBER	31.9	21.7	33.9	22.5	33.3	22.4	33.4	22.7	34.0	229.0
NOVEMBER	32.2	21.8	33.5	21.9	31.2	21.2	33.3	23.1	32.8	22.6
DECEMBER	31.4	20.5	31.3	22.6	32.2	20.4	32.5	21.7	32.1	21.1

3.6 WILDLIFE AND VEGETATION

3.6.1 INTRODUCTION

The proposed construction of the RDA will occupy an estimated 100 hectares of land adjacent to RDA 4. The previous four lakes cover an estimated area of 210 hectares (519 acres). The areas in proximity to the walls of the RDAs and the lands behind them that extend to the river, support a vegetation type typical of a scrubland/ thorn savannah. In most areas, the physiognomy of the plant communities are very similar. Whilst in others the structure of the vegetation has been modified by specific events or activities such as old excavations, grazing, tree felling for charcoal burning or post making, and even flood events. The area, although in proximity to the Rio Minho, appears to be dry. This is evident with the existing plant community that demonstrates xerophytic adaptations such as thick land shiny cuticles, small leaves or succulent parts.

The map and table below shows sample locations and coordinates at Hayes.

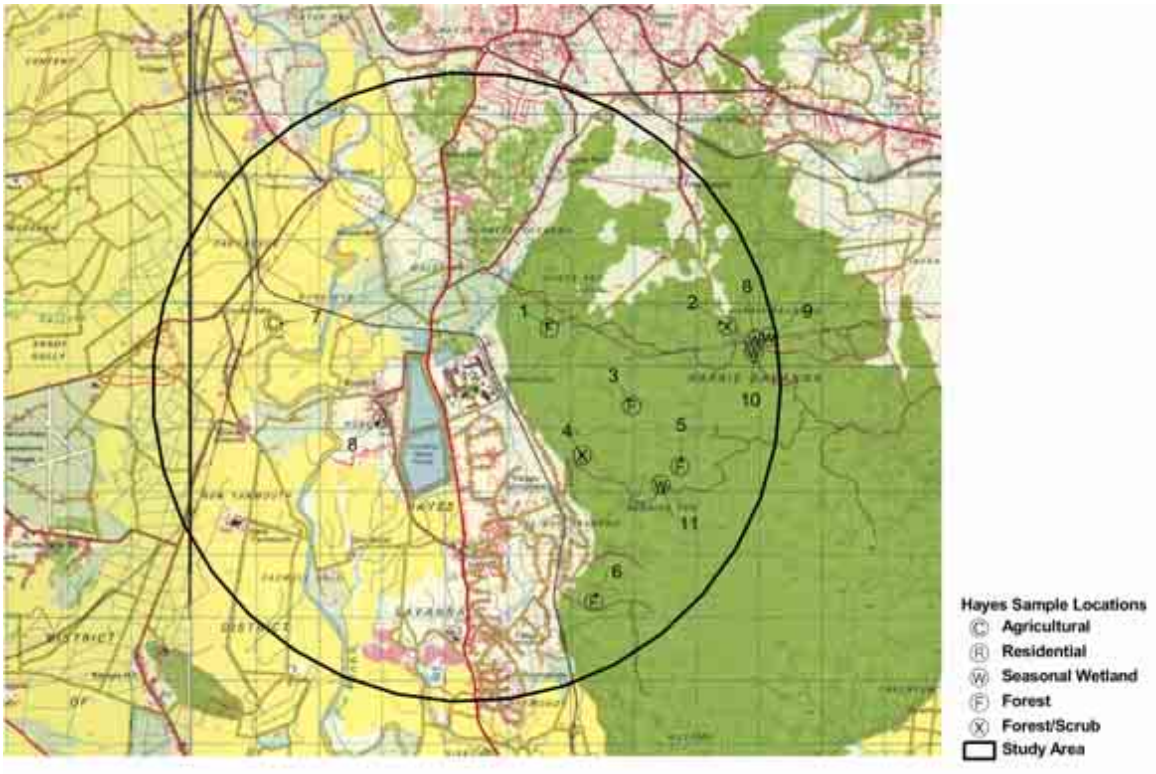


FIGURE 3-20: : MAP SHOWING SAMPLE LOCATIONS AT HAYES, CLARENDON

TABLE 3-20: COORDINATES OF SAMPLE SITES AT HAYES, CLARENDON (COORDINATES CORRESPOND TO 1:50,000 METRIC MAP)

ID HAYES	TYPE	X	Y
1	Woodland	225,665	139,600
2	Woodland/Scrub	228,497	139,634
3	Woodland	226,978	138,356
4	Woodland/Scrub	226,193	137,584
5	Woodland	227,740	137,401
6	Woodland	226,373	135,248
7	Agricultural	221,270	139,679
8	Seasonal Wetland	228,934	139,417
8	Residential	223,016	138,160
9	Seasonal Wetland	229,160	139,452
10	Seasonal Wetland	228,916	139,208
11	Seasonal Wetland	227,432	137,113

3.6.2 METHODOLOGY

The ecological assessment was conducted primarily through qualitative methods supported by literature research. The literature review was based on a series of relatively current studies which employed the use of quantitative methods for several areas in the sphere of influence of the project sites. Methods employed included the following:

- Aerial photography and land use classification mapping to identify plant species distribution and classification.
- Ground- truthing to confirm land use classification and vegetation type and distribution
- Plant collection and plant identification through the aid of a recognized taxonomist and herbarium
- Literature research of information related to the geographical influence of the proposed project to generate species inventories.
- Animal identification through field guides, photography, vocalization, tracks, faecal deposits, burrows among others.

3.6.3 ECOLOGICAL CONTEXT

3.6.4 NATIONAL BIOLOGICAL DIVERSITY – INTERNATIONAL AND NATIONAL LEVELS

Jamaica is rated fifth highest in endemic plants of any island, worldwide. Based on information through the National Strategy and Action Plan on Biological Diversity in Jamaica (2003), of the 3,304 known vascular species to occur in the country at least 28% are endemic.

TABLE 3-21-Flora diversity[i]

Terrestrial flora	# of indigenous species	# of endemic species	% endemicity
Bromeliads	60	22	36.7
Orchids	230	60	26
Ferns	579	67	11.5
Cacti	20	10	50
Palms	10	7	70
Grasses	~200	1	0.5

Faunal species similarly have high levels of endemicity with land birds showing 45% and amphibians and reptiles showing a 100% and 76%, respectively.

TABLE 3-22- Fauna diversity[i]

Terrestrial fauna	# of indigenous species	# of endemic species	% endemicity
Land snails	514	505	98.2
Grapsid crabs	9	9	100
Jumping spiders	26	20	76.9
Fireflies	48	45	93.8
Butterflies	133	20	15
Ants	59	6	10.3
Amphibians	22	22	100
Reptiles	43	33	76.7
Shore & Seabirds	39	1	2.6
Land birds	67	30	44.8
Bats	21	2	9.5
Other mammals	2	2	100

In order to protect this diversity, the Government, through the Forestry Department, has entered into an arrangement with Jamalco, guided by a 'no-net-loss' policy where the two organizations will work to compensate for the loss of forest cover due to mining operations. This will see the establishment of new forests on selected reclaimed bauxite mined out areas as well as the protection and preservation of existing forests. The full text of the MOU is presented in APPENDIX IV

3.6.5 FINDINGS

3.6.5.1 SAMPLE LOCATIONS

The following locations were selected as representative of the different ecosystem identified during the reconnaissance. The selected sample sites are indicated on the accompanying maps.

3.6.5.1.1 HAYES FACTORY PERIMETER

The circular perimeter of 5 km radius around the Hayes factory is subdivided into a western agricultural and eastern woodland area, the latter forming a part of Harris Savanna. Residential areas mainly stretch along the main road that runs southwards from Curatoe Hill trough Hayes and towards Lionel Town. To the east of the road, the bed of Rio Minho meanders southward.

Growing on top of flat though often rugged limestone, the woodland consists of a mosaic of secondary scrub dominated by exotic plants and degraded dry limestone forest of varying quality. Secondary scrubs are most common in the most northern section of the area and along drive roads. The least disturbed dry forest is found away from drive roads and footpaths. Shallow depressions filled with alluvial deposits intersect the limestone. These soil-rich areas are mostly clear-cut and covered with grassy plants. Prone to flooding, they contain a series of seasonal wetlands that support a unique flora.

The agricultural and residential areas are located on the Clarendon alluvial plain. They have lost their natural vegetation in the distant past and are dominated by exotic plants. The major crop species is sugar cane.

Location 1 and 2 - Strongly disturbed limestone forest with only few tall trees, mainly Red Birch. Dense and rather scrubby, but with many native species typical of mature forest.

Locations 2 and 4 - Mixture of strongly disturbed limestone forest dominated by native species and secondary scrub dominated by exotics.

Locations 3 and 5 - Located within a section of least disturbed forest. A variety of tree species grow to considerable height. Some patches close to undisturbed forest.

Location 7 - Agricultural area dominated by sugar cane and pastures.

Location 8 - Residential area dominated by exotic fruit trees and ornamental species.

3.6.5.2 DESCRIPTION OF VEGETATION TYPES

The vegetation was generally what is expected in highly disturbed areas.

The ecology of this site and the areas along the railway leading to the alumina plant reflects plant species exposed to dry and hot conditions which may be generally described as Thorny scrub. Many of the water conservation measures employed by species in the coastal areas, described below, were noted here. The dominant species was Wild poponax (*Acacia tortusa*) which had an even distribution. Specimens were found to be of an average height of 3 m (9ft). The plants were highly branched with deep canopies, accounting for an estimated 60% of the plants height. However, the plants did not form a continuous canopy. An herb or sub-canopy was not represented in the scrub area. However, Seymour grass (*Andropogon pertusus*) was quite common. The species list is presented in Table 4-3-23: Thorn Scrub below.

TABLE 4-3-23: THORN SCRUB

Family Name	Scientific Name	Common Name	Status/Rank	Habit
Amaranthaceae	*Achyranthes indicia*	Devil's horse whip	Widespread	Annual herb
amaranthaceae	*Gomphrena decumbens*	None	Common	Herb
Anacardiaceae	*Mangifera indicia*	Mango	Cultivated/Naturalized	Tree (5-10m)
Anacardiaceae	*Anacardium occidantale*	Cashew	Cultivated	Tree (4-8m)
Asclepiadaceae	*Calotropis procera*	Dumb cotton	Widespread	Shrub/Tree (4-6m)
Boraginaceae	*Ehertia tinifolia*	Bastard cherry	Fairly common	Tree (6-15m)

Family Name	Scientific Name	Common Name	Status/Rank	Habit
Cactaceae	*Harrisia gracilis*	Torchwood dildo	Common	Shrubby cactus (2-6m)
Caesalpiniaceae	*Haemotoxylum campechianum*	Logwood	Common/Naturalized	Tree (10m)
Commelinaceae	*Commelina diffusa*	Water grass	Widespread	Weed
Compositae	*Eupatorium spp*	None		Usually a Shrub
Euphobiaceae	*Jatropha gossypiifolia*	Belly-ache Bush/Cassada Marble	Common	Shrub (60-120cm)
Fabaceae	*Crotalaria retusa*	Rattle weed	Common	Shrubby herb (1m)
Malvaceae	*Sida acuta*	Broom weed	Common	Under shrub
Mimosaceae	*Leucaena leucocephala*	Lead Tree	Widespread	Shrub/Tree (3-6m)
Mimosaceae	*Mimosa pudica*	Shame-a-Lady/Shame weed	Widespread	Weed (30-100cm)
Mimosaceae	*Samanea saman*	Guan go	Common/Naturalized	Tree (16m)
Mimosaceae	*Acacia tortusa*	Wild poponax	Common	Shrub/Tree (3-5m)
Nyctaginaceae	*Pisonia aculeate*	Cockspur/Wait-a-bit/Fingrigo	Same	Shrub (6m)
Orcidaceae	*Broughtonia sanguine a*	Orchid	Common	Epiphyte
Poaceae	*Andropogon pertusus*	Seymour grass	Widespread	Grass, stoloniferious
Poaceae	*Axon opus compressus*	Carpet grass	Widespread	Grass, stoloiferous
Sapindaceae	*Blighia sapida*	Ackee	Same	Tree (8-15m)
	None	Callaloo	Cultivated	Shrub

The Rio Minho River runs through a section of the study area. Vegetation flanking the river showed a marked difference to that found on the plains. The height, diversity and density of the plant species were much greater and the proximity to water resources is undoubtedly a contributing factor. Aquatic and hydrophilic plants represented the only variation from xerophytic vegetation and naturally their distribution was limited to the waterbodies and waterways traversing the Thorn Scrub. Tree species found in close proximity to the river included Guango, Ackee and Mango. Other noticeable plants found close to the water edge included reeds (*Typha domingensis*) and water grass (*Commelina diffusa*).

General trends observed in the vegetation found in proximity to the RDA were as follows:

- Vegetation height of Wild Poponax increased with distance from the access road with an average height of 2.6m (8.5ft) (Figure x)
- Areas of bare ground were mainly as a result of pathways

Sugarcane fields to the south of the RDA could come within the sphere of influence during the construction phase of the RDA.

PLATE 3-2: TYPICAL STANDS OF WILD POPONAX FOUND ON AND AROUND RDAS

Summary

Sixteen plant families were recorded accounting for twenty-four species. One endemic species was noted, *B. sanguinea*, a common orchid.

3.6.5.3 FAUNAL STUDIES

3.6.5.3.1 4.6.6.3 GENERAL FAUNAL DESCRIPTION

The primary focus of the faunal studies was on the avifauna in the area and for the other species noted such as insects, reptiles and amphibians. Analysis of avifauna species was conducted in relation to habitat types as outlined above in the vegetation analysis.

The vegetation types identified in the study area have the potential to support a number of bird species, providing habitats particularly for columbids, and passerines. The vegetation types have also been known to support a large number of migrant warblers in the winter season.

Generally, bird counts conducted over the study period did not confirm a large number of bird species and only one migrant was identified in the total of fifteen (15) species identified.

TABLE 3-24: Coastal and Thorn Scrub

FAMILY NAMES	SCIENTIFIC NAMES	COMMON NAMES	STATUS/ RANK	FEEDING HABIT
Apodidae	*Tachornis phoeicobia*	Antillean Palm Swift	R1	Insectivore
Apodidae	*Streptoprocne zonaris*	White-Collard swift	R1	Insectivore
Ardeidae	*Bubulcus ibis*	Cattle Egret	R1	Omnivore
Cathartidae	*Cathartes aura*	Turkey Buzzard	R1	Scavenger
Charadriidae	*Charadrius vociferous*	Killdeer	R1	Omnivore
Columbidae	*Columbina passerine*	Ground Dove	R1	Frugivore
Columbidae	*Zenaida aurita*	Mourning Dove	R1	Frugivore
Cucilidae	*Crotophaga ani*	Smooth-billed Ani	R1	Omnivore
Emberizinae	*Tiaras olivacea*	Yellow-faced Grassquit	R1	Frugivore
Falconidae	*Falco sparverius*	American Kestrel	R1	Carnivore
Mimidae	*Mimus polyglottos*	Northern Mockingbird	R1	Omnivore
Scolopacidae	*Actitis macularia*	Spotted sandpiper	W1	Omnivore
Sturnidae	*Sturnus vulgaris*	European Starling	I1	Frugivore
Trochilidae	*Mellisuga minima*	Vervain	R1	Nectarivore
Tyrannidae	*Tyrannous dominicensis*	Gray Kingbird	S1	Insectivore

Families -13
Species - 15
Endemics -none

3.6.5.4 OTHER FAUNA

Insects were fairly well represented, with butterflies and bees being the most obvious of the group. Lepidoptera (butterflies etc.) were represented with at least 5 different species noted. More importantly is the ecological functions of these insects where they act as pollinators. Other insect's species included ants, beetles, stinkbugs, wasps and honeybees.

3.6.5.4.1 AMPHIBIANS AND REPTILES

Reptiles and amphibian were not noted during surveys however literature reviews indicated the likely occurrence of certain species in the study area. Please refer to the list below, which a list of potential amphibians and reptiles in study area.

Serpentes

- ✓ *Arrhyton funereum* - endemic
- ✓ *A. callillaemum* - endemic
- ✓ *Typhlops jamaicensis* - endemic

SPHAERODACTYLUS

- ✓ *Sphaerodactylus argus* – not endemic

Celestus

- ✓ *Celetes duquesneyi* - endemic
- ✓ *C. d crusculus* - two subspecies – endemic
- ✓ *C. barbouri*

Anolis

- ✓ *Anolis valencienni* - endemic
- ✓ *A. sagrei*

***A OPALINUS* - ENDEMIC MAYBE EXTINCT**

- ✓ *A. lineatopus* - endemic

***A. GRAHAMI* - ENDEMIC INTRODUCED TO OTHER ISLANDS**

- ✓ *A. garman i*- endemic introduced to other islands

Sauria

- ✓ *Ameiva dorsalis*

Testudines

- ✓ *Trachemys terrapen*

Amphibia

- ✓ **Anura**
  - o *Osteopilus brunneus* - endemic
  - o *Hyla wilderi* - endemic
  - o *Hyla marianae* - endemic
  - o *Bufo marinus* - introduced
- ✓ *Eleutherodactylus planirostris planirostris*
- ✓ *E. pantoni pantone*
- ✓ *E.junori* - endemic
- ✓ *E.jamaicensis* - endemic
- ✓ *E.grabhami* **-** endemic
- ✓ *E gossei gossei* - endemic
- ✓ *E. gossei oligaulax* - endemic
- ✓ *E. cundalli* - endemic
- ✓ *E. cavernicola* - endemic
- ✓ *E. calyptahyla crucialis* **-** endemic

At least four species of *Arrhyton sp* of which three are endemic. The snakes feed on other reptiles and amphibians such as *Anolis spp, Eleutherodactylus* adults and eggs as well as *Sphaerodactylus spp*. Of the *Sphaerodactylus spp* one, not endemic, has a range extending to the study area.

In addition, at least six *Anolis spp* are suspected to occupy the area. Of these six species at least five are endemics with one species thought to be extinct. Our largest reptile *C.acutus* has also been reported in the Portland Bight area.

Of the amphibians at least 15 species are thought to have the potential to occur in the study area and of these fifteen, twelve are endemic. Furthermore, nine of those species are *Eleutherodactylus spp.*

3.6.5.4.2 BUTTERFLIES

As with amphibians and reptiles, this group was not surveyed and unfortunately literature did not yield concrete data on species distribution. Information from the Begs report 2000, which focused on faunal studies in Southern Manchester, indicated the likely occurrence of certain species. The report identified seven families accounting for 41 species. Of which nine are endemic species or subspecies.

3.7 ARCHAEOLOGICAL AND HISTORICAL RESOURCES

3.7.1 SUMMARY [ii]

The parish of Clarendon was named in honour of the celebrated Lord Chancellor of England & Wales. The parish of Vere, now merged in it, was named after Vere, daughter of Sir Edward Herbert, Attorney General to Charles I, and first wife of Sir Thomas Lynch, who, with her two sons, died on her passage from England to Jamaica in 1683.

Carlisle Bay, the scene of the principal military engagement with a foreign foe which has taken place in Jamaica during the British occupation, is on the south-west coast of the old parish of Vere.

3.7.2 BUILDINGS AND MONUMENTS OF ARCHITECTURAL AND HISTORIC INTEREST

There are various buildings and monuments of architectural and historic interest in the parish of Clarendon. Some of these are listed below.

- Halse Hall Great House
- Churches, Cemeteries, Tombs'
- St. Peter's Church, Alley
- Clock Tower
- May Pen Clock Tower

3.7.3 NATURAL SITE

- Milk River Spa

3.7.4 PROTECTED NATURAL HERITAGE SITES

3.7.4.1.1 NATURAL SITE

- Mason River Botanical Station

3.7.4.1.2 OTHER HERITAGE SITES[iii]

3.7.4.1.2.1 Arawaks

In Clarendon, they lived in Portland Ridge (the part of the parish that juts out into the sea) as well as in the Braziletto Mountains and on Round Hill. There was also a village on the banks of the Rio Minho near Parnassus Estate and the others were on the banks of the Milk River.

3.7.4.1.2.2 Halse Hall Great House

Halse Hall Great House, believed to be built on the site of a house that stood on the Site of Buena Vista, was acquired by Thomas Halse in 1655 who came to Jamaica with Venables. Henry de la Beche, one of its many owners was the founder of the Geological Survey of Great Britain. He made detailed Geological notes of the places he visited in Jamaica. In 1969 the estate was acquired by ALCOA, the house renovated by them. It is now the property of the National Trust.

3.7.4.1.2.3 St. Peter's Church Alley

St. Peter's Church Alley, is the 3rd oldest Anglican Church in Jamaica. Built in 1671, it became the Parish church for Vere in 1673 it was extensively damaged by the 1692 earthquake and had to be almost totally rebuilt in 1975

3.7.4.1.2.4 Morgan's Valley and Estate

Sir Henry Morgan, a privateer, buccaneer and former Governor of Jamaica, owned Morgan's Valley and Estate. He lived there while he was Governor of Jamaica.

3.7.4.1.2.5 May Pen Clock Tower:

May Pen Square is over 80 years old. It was constructed in honor of Dr. Samuel Glaister Bell, a renowned doctor of the parish who lost his life while crossing the Rio Minho after visiting a patient. The May Pen Clock Tower is made of stone. It is approximately twenty-four (24) feet in height, eight feet (8) in width, and eight feet in length. The exact date of its erection has not been ascertained, but it appears to have been constructed after World War II.

3.7.4.1.2.6 St Gabriel's Anglican Church

Once called Lime Savannah Chapel, was the "daughter" Church of St. Paul's in Chapelton. When the Church of the White Cross fell into disuse, St. Gabriel's took its place.

3.7.4.1.2.7 St. Paul's Church- Chapleton

When the present parish of Clarendon was divided into the parishes of Clarendon and Vere, the Cross church was then the parish church of Clarendon. St. Paul's was built as a chapel of Ease to the Cross Church, and was the first place of worship erected in Upper Clarendon. It was originally known as "the Chapel". It took the name from the church, being called "Chapel Town," and in the course of time shortened to its present form, Chapleton.

3.8 NOISE LEVELS AND VIBRATION

3.8.1 BASELINE NOISE LEVELS

Noise levels are measured on a reasonably regular basis at the existing RDAs. Recently, these measurements have been taken in support of the Step-in-dyke being constructed in RDA 1. Recent data from the RDAs taken during active operation of heavy equipment (track excavators, loaders, bulldozers and trucks) follows.

The audiometric survey was conducted using a Metrosonic audio dosimeter. The survey points were triangulated around RDA 1 (See Plate 3-3 below), along the RDA #1 perimeter wall. The audiometer was operated continuously throughout the duration of the survey, with instantaneous readings for the Sound Pressure Levels (SPL) being recorded at one minute intervals, or at a moment of significant activity,1 over a period of fifteen (15) minutes each.

Table 3-25, Table 3-26, and Table 3-27 show the instantaneous measurements for the SPL levels which were recorded from the audiometer at the three survey points indicated in Plate 3-3 below.

[1] Significant activity is to be defined as, any activity which affects the audiometer's SPL measurement such that it deviates from the instantaneous 'background' effecting activity.

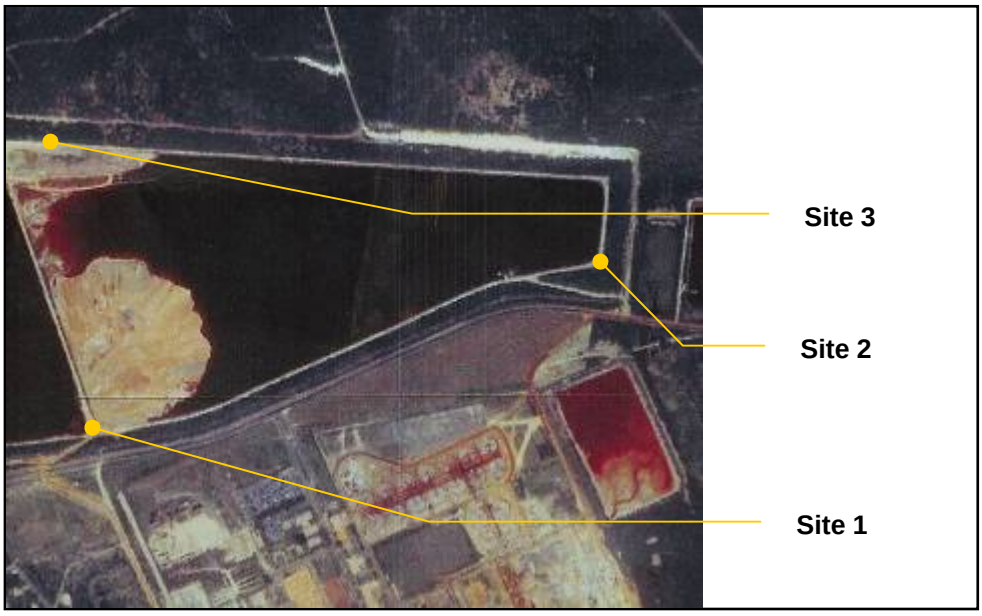


PLATE 3-3: AUDIOMETRIC SURVEY SITES AROUND RDA # 1[2]

3.8.1.1 SOUND PRESSURE LEVEL (SPL) ANALYSIS

3.8.1.1.1 SITE 1

The average SPL value at site 1 was calculated as 62.6 db. There were only two occasions when the 70.0db limit was exceeded; however, only on one of the two exceedances was due to the operation of heavy the equipment, whereas the other was due to inherent background activity such as wind. It should be noted that the occasion which generated the highest SPL value was the instantaneous and continual inherent background activity, which is beyond the control of Jamalco.

[2] Please note that the aerial picture does not represent the RDA's present state. It is only to be used as a guide to indicate the audio metric survey points

TABLE 3-25: SITE 1 SPL VALUES

Time/ mins	SPL/ db	Effecting Activty
0	61.6	Background (2)
0-1	70.7	Caterpiller Grader
1	62.6	Background (2)
2	73.2	Background (2)
3	66.2	Truck Traveling along Highway
4	59.1	Background (2)
4-5	66.7	Truck Carrying Reject Material
5	63.4	Background (2)
6	61.5	Background (2)
7	59.2	Background (2)
8	59.3	Background (2)
9	62.9	Background (2)
10	61.1	Background (2)
11	66.4	Passing Truck
12	61.6	Background (2)
13	53.6	Lull in Wind
14	60.0	Background (2)
15	58.2	Background (2)
Average	**62.6**	

Table Notes

- Time ranges displayed as x-y are to be perceived as any time measurement between x and y
- The "Effecting Activity" labeled as "Background (1)" is defined as perpetuating noise from continuous wind movement across the microphone.
- Information in blue font represent "Significant Activity" and information in red font represent exceedances above the 70db limit

3.8.1.1.2 SITE 2

In the absence of significant construction activity, the contributing agent to the variation of the SPL values would be the random activity which occurs in the background. The terrain at Site 2 is such that there is a thick growth of epiphytes along the outer area of the dyke's perimeter wall. This growth was observed to act as buffer to the prevailing winds, resulting in the diminished effects of the prevailing wind on the SPL levels measured by the audiometer at Site 2. The effect of the diminished wind activity at Site 2 is reflected in the average SPL values observed at Site 2 and Site 3. (See Table 3-26 and Table 3-27 below)

TABLE 3-26: SPL VALUES FOR SITE 2

Time/ mins	SPL/ db	Effecting Activity
0	66.9	Background (2)
1	73.2	Passing Trucks on Highway
1-2	53.2	Lull in Wind
2	60.1	Background (2)
3	54.4	Lull in Wind
4	53.8	Lull in Wind
4-5	65	Horn of Bauxite Rail
5	65.7	Background (2)
6	65.4	Background (2)
7	56.5	Background (2)
8	63.5	Background (2)
9	54.6	Background (2)
10	60.0	Passing Vehicle on Highway
11	55.6	Background (2)
12	57.6	Background (2)
13	60.4	Background (2)
14	67.0	Background (2)
15	57.1	Background (2)
Average	**60.6**	

Table Notes

- Time ranges displayed as x-y are to be perceived as any time measurement between x and y
- The "Effecting Activity" labeled as "Background (2)" is defined as perpetuating noise from continuous wind movement across the microphone.
- Information in blue font represent "Significant Activity" and information in red font represent exceedances above the 70db limit

3.8.1.1.3 SITE 3

The terrain at Site 3 is an open flat area with no buffer or vegetation alongside the perimeter of the original RDA #1 wall. Therefore, the wind passes over the land unhindered.

A comparison between SPLs for Site 1, Site 2, and Site 3 reveal that Site 3 consistently has higher SPLs either Site 1 or Site 2. This is due to the accessibility and/or the vulnerability to the area to the prevailing wind for the reason described above. It should be noted that the influence of the wind activity is especially evident in the average SPL value recorded at Site 3, which is only 1 db below the defined standard of 70db.

Therefore, one may conclude that the SPL levels at the site are greatly influenced by the naturally occurring wind activity, and may elevate SPL values above the 70db limit. The likely occurrence of such events is beyond the control of Jamalco.

TABLE 3-27: SPL VALUES FOR SITE 3

Time/ mins	SPL/ db	Effecting Activty
0	73.4	Background (2)
1	69.3	Background (2)
2	57.9	Background (2)
3	71.1	Background (2)
4	66.6	Background (2)
5	64.4	Background (2)
6	70.2	Background (2)
7	61.5	Background (2)
8	79.7	Background (2)
9	75.6	Background (2)
10	69.7	Background (2)
11	66.4	Background (2)
12	61.0	Background (2)
13	66.4	Background (2)
14	74.1	Background (2)
15	77.0	Background (2)
Average	**69.0**	

Table Notes

- Time ranges displayed as x-y are to be perceived as any time measurement between x and y
- The "Effecting Activity" labeled as "Background (2)" is defined as perpetuating noise from continuous wind movement across the microphone.
- Information in blue font represent "Significant Activity" and information in red font represent exceedances above the 70db limit\

were determined by identifying communities that might be impacted during the various phases of this project. The communities' were identified through field surveys and aerial photographs.

The selected areas were monitored using a digital audiometer (Quest Electronics Model 2700, Impulse Sound Level meter) with a wind screen. The instrument was calibrated using a supplied calibrator prior to being used.

A total of x locations were identified and monitored to determine baseline noise levels. The selected sites monitored are:

Location 1:

Location 2:

Location 3:

Location 4:

3.8.2 AUDIOMETRIC SURVEY

Survey results…… TO FOLLOW

3.8.3 VIBRATION ANALYSIS

The proposed impact of vibration associated with the proposed earthworks are not expected to carry into the bordering communities of Hayes and Hayes Cornpiece. Any vibration associated with the potential blasting exercises will be monitored along with the usage of the explosives to effectively minimise the possibility of adverse effects.

3.9 NATURAL HAZARD VULNERABILITY

3.9.1 NATURAL HAZARD VULNERABILITY

3.9.1.1 FLOODING

Specific records of flooding in the Rio Minho floodplain date back to 1886, reported in the Tri-Weekly Gleaner, June 19, 1886 (Rowe, 2004, in preparation), when heavy rains in June of that year led to what was believed to be the worst flooding on record for that river. The river was 40 ft (12.2 m) deep at the May Pen Bridge, some 4 ft higher than the previous record, and did immense damage to roads and property. Affected localities included Halse Hall and Parnassus and Caswell Hill.

The worst flood event of the 20th century occurred in 1986, when rainfall within the Rio Minho catchment caused the river to overflow its banks to cover wide areas of the Rio Minho Alluvial Fan. The approximate extent of this flood event is inserted on Figure 3-21. According to the Water Resources Authority, this event had an estimated return period of 100 years.

The most notable feature of the flood water extent is that north of Kemps Hill the flooding was confined to a relatively narrow floodplain, whereas south of Kemps Hill the flood waters spread out over a wide area. This is a reflection of the fact that the river is incised into the upper part of the fan, while in the southern part, Vere Plains, it is not. It is suggested that this may be a function of continuing movements along the South Coast Fault.

With respect to the plant and RDA area (Figure 7), the risk from flooding is low, due to the fact that these are constructed on the high terrace of the well-drained, relatively thin

Hayes Gravels. During the June 1986 flood event the only part of the plant that was flooded was the low-lying storm lake at the northern end of the RDAs.

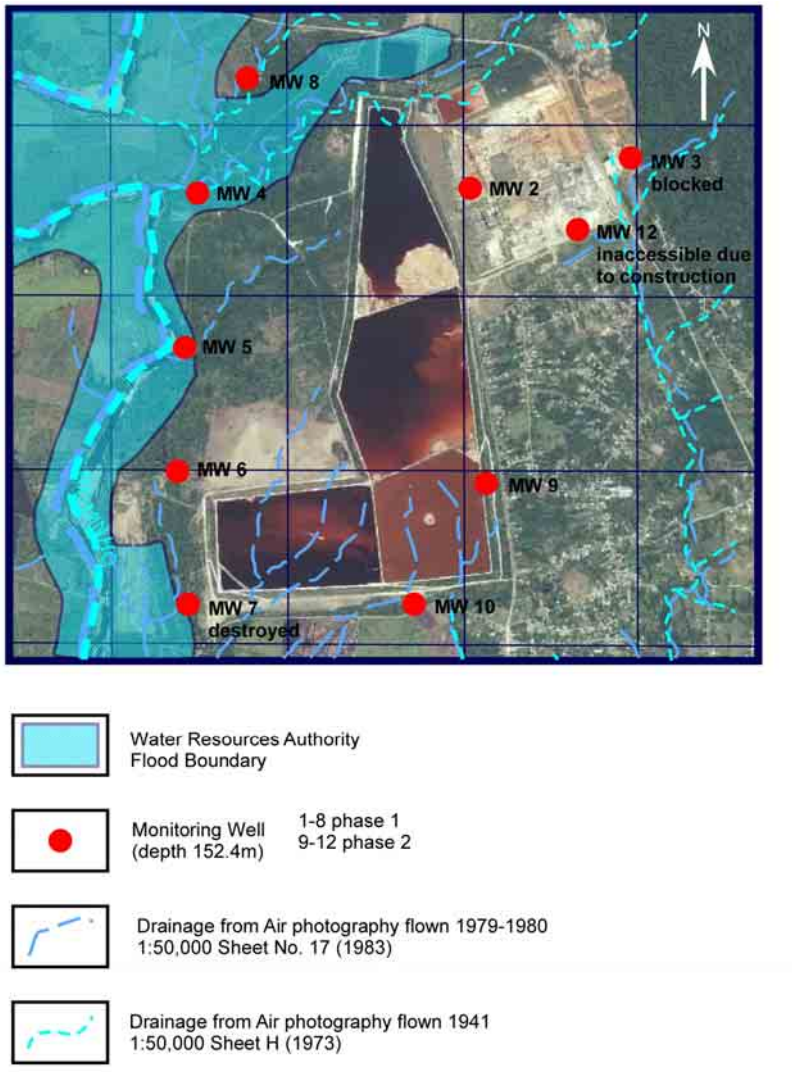


FIGURE 3-21: 1986 FLOOD BOUNDARY AND MONITORING WELLS AT THE REFINERY.

Using data from the Trout Hall rainfall station in the Upper Rio Minho Basin an analysis of the maximum 24hr rainfall depths for the 10, 25, 50, and 100yr return period floods was undertaken by the Water Resources of Jamaica (WRA) (Table 3-28). Data from the Trout Hall rainfall station was used because it is generally located in the Upper Rio Minho Watershed and it best represents the rainfall distribution over the watershed.

TABLE 3-28: 24HR RAINFALL BASED ON DATA FROM THE TROUT HALL RAINFALL STATION[3]

Storm Duration	1950 – 1986 Data (Trout Hall) (mm)			
	10yr	25yr	50yr	100yr
1min	17.9	21.7	28.5	30.4
15min	37.3	45.1	59.3	63.2
1hr	71.8	86.8	114.0	121.5
2hr	97.6	119.4	162.5	177.8
3hr	107.2	131.5	180.5	198.8
6hr	123.4	151.9	211.0	234.2
12hr	143.0	176.6	247.8	277.7
24hr	**175.0**	**217.0**	**308.0**	**347.0**

The profiles for the 10 – 100yr floods used by WRA were developed using the Steady flow analysis and one-dimensional flow methodology. Input data utilised information such as cross-sections of river channels. There are eight hydraulic structures on the Webbers Gully that could affect flow, none on the Rio Minho in the vicinity of the proposed development. Eight (8) parallel and identical circular culverts, each with a diameter of 3.96m serve as conveyance capacity at two locations on the Webbers Gully, located at the Alcoa train line and at the main road from Hayes to May Pen. The starting water surface elevations for the simulation of flood levels for Webbers Gully are presented in Table 3-29.

TABLE 3-29: STARTING WATER SURFACE ELEVATIONS AT THE WEBBERS GULLY/RIO MINHO RIVER JUNCTION[4]

Return Period (yr)	Peak Flow (m3/s)	Water Surface Elevation (m) a.m.s.l.
	Webbers Gully	Rio Minho River
10	86	33.35
25	111	34.66
50	129	35.51
100	145	36.17

Using a Hydrologic Engineering Center River Analysis Systems (HEC-RAS) modelling software developed by the US Corps of Engineers and the following scenarios, revealed:

[3] Part of Rio Minho River/Webbers Gully Floodplain Mapping Project, Prepared by Water Resources Authority, June 2005
[4] Part of Rio Minho River/Webbers Gully Floodplain Mapping Project, Prepared by Water Resources Authority, June 2005

1. Scenario 1: the culverts are free of debris and any other obstruction that may restrict flow,
2. Scenario 2: the capacity of the culverts was approximately 50% blocked by debris, and
3. Scenario 3: the capacity of the culverts was nearly 100% blocked by debris

Flood plain Maps (Figure 1-1, Figure 3-23, and Figure 3-24) show the outcome of the above scenarios.

The Alley Bridge, which is approximately 2km downstream of the proposed site, had no effect on flood levels even with the bridge opening completely blocked. The WRA found that there was no significant inundation on either side of the Webbers Gully by any flood events modelled. There was general overtopping of the left bank of the Webbers Gully in all three scenarios by the flood events along the reach extending from the train line to the main road. However, there was only significant overtopping of the right bank if the culverts are blocked. Flood duration for the 50 and 100yr events along the Webbers Gully are expected to last for approximately 3 to 4 hours when culverts are clear.

ODPLAIN MAP - CLARENDON
ne - Rio Minho River)
ne & Main Road Modeled Free of Debris)

TH T-YEAR FLOODS
Maximum 24hr Rainfall (mm)
217
269
308
347

Datum: JAD2001
Coordinate System: WGS 1984
Projection: Lambert Conformal Conic
Central Meridian: -77
Latitude of Origin: 18
Standard Parallel 1: 18
Standart Parallel 2: 18
False Easting: 750000
False Northing: 650000

Scale 1:3,500

0.05 0 0.05 0.1 0.15 Kilometers

Topographic Base Map: KOMO1 Satellite Image (2001)

LOCATION MAP

WEBBERS GULLY FLOODPLAIN MAPPING PROJECT

Prepared by: L. Barrett — Engineer/Hydrologist

Assisted by: H. Thomas — Dir. Resource Management
A. Hiduk — Water Resources Engineer
E. Douglas — Senior Assistant Hydrologist
H. Roper — Assistant Hydrologist

CLIENT: ALCOA MINERALS JAMAICA, INC. (JAMALCO)
KIER/CCC

PART OF WEBBERS GULLY AND RIO MINHO RIVER FLOODPLAIN MAPPING

Water Resources Authority
Hope Gardens
P.O. Box 91
Kingston 7
Jamaica

Date: June 2005

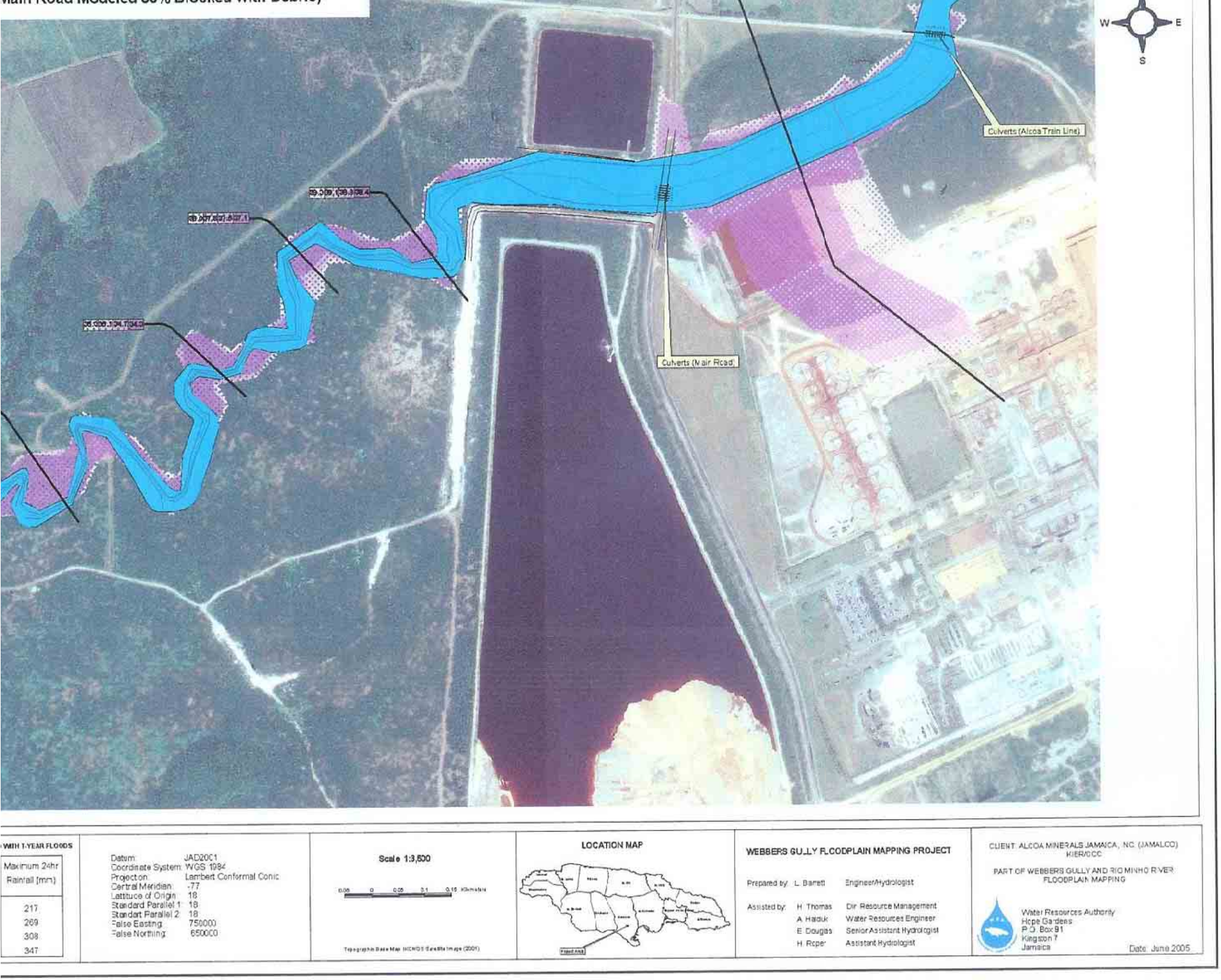


FIGURE 3-23: OUTCOME OF SCENARIO 2

AR FLOODS

n 24hr	
(mm)	

Datum: JAD2001
Coordinate System: WGS 1984
Projection: Lambert Conformal Conic
Central Meridian: -77
Lattitude of Origin: 18
Standard Parallel 1: 18
Standard Parallel 2: 18
False Easting: 750000
False Northing: 650000

Scale 1:3,600

0.05 0 0.05 0.1 0.15 Kilometers

Topographic Base Map: IKONOS Satellite Image (2001)

LOCATION MAP

WEBBERS GULLY FLOODPLAIN MAPPING PROJECT

Prepared by: L. Barrett — Engineer/Hydrologist

Assisted by: H. Thomas — Dir. Resource Management
A. Haduk — Water Resources Engineer
E. Douglas — Senior Assistant Hydrologist
H. Roper — Assistant Hydrologist

CLENT: ALCOA MINERALS JAMAICA, INC. (JAMALCO)
KIER/CCC

PART OF WEBBERS GULLY AND RIO MINHO RIVER FLOODPLAIN MAPPING

Water Resources Authority
Hope Gardens
P.O. Box 91
Kingston 7
Jamaica

Date: June 2005

3.9.1.2 LANDSLIDES

There appear to be no historical records of landslides in the district. While no detailed assessment of the landslide susceptibility has been carried out in southern Clarendon to date, the landslide susceptibility map of southern Clarendon (Figure 3-25) indicates low susceptibility levels at Hayes. This can be attributed to the flat lying nature of the topography, the presence of fairly easily drained alluvial soils, and the relative dry climate.

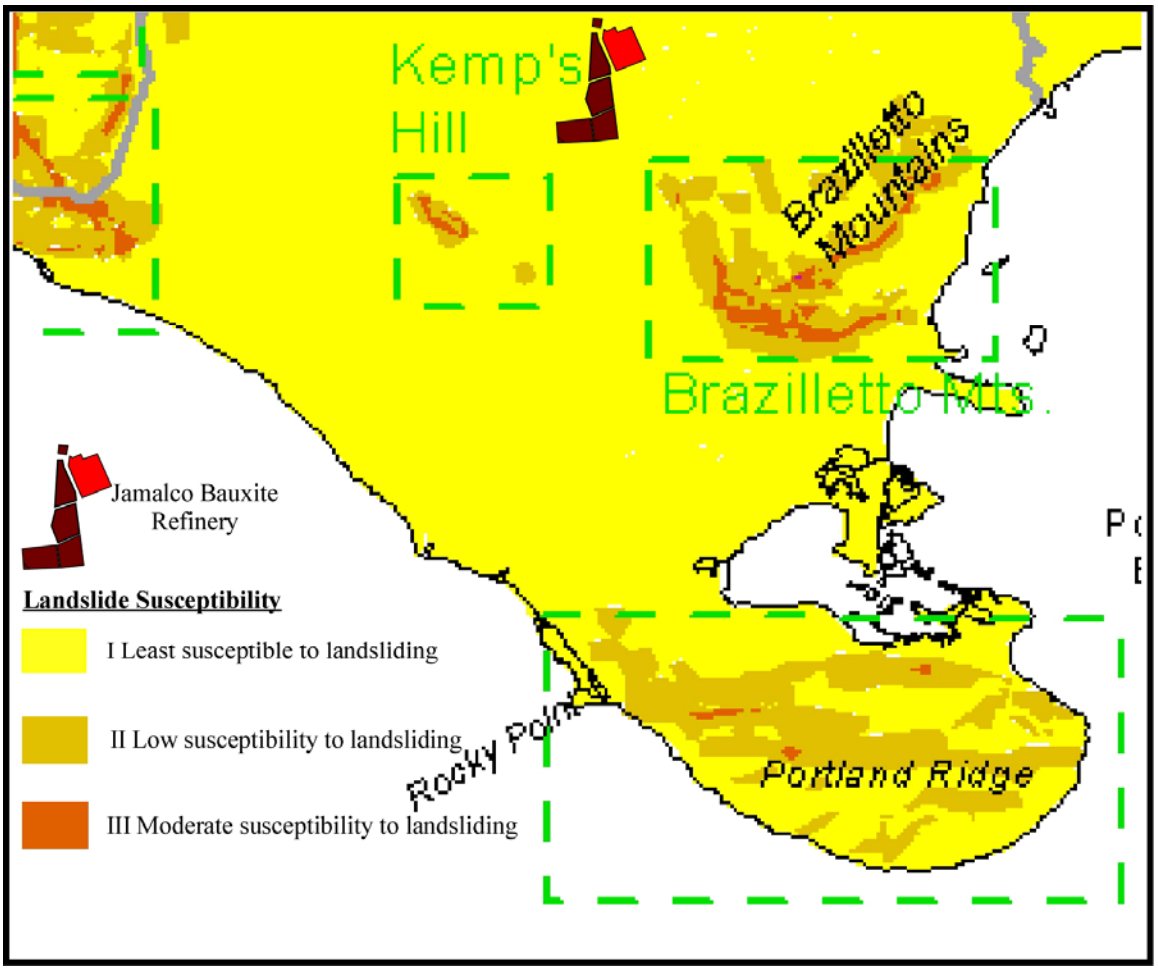


FIGURE 3-25: LANDSLIDE SUSCEPTIBILITY MAP OF SOUTHERN CLARENDON (SOURCE: SOUTH COAST DEVELOPMENT PROJECT.)

The design and construction of the dykes impounding the present RDAs appear to be sound, with no reports of slumping or collapse. The slopes of the dykes are subject to erosion from rainfall, taking the form of vertical runnels. The attempts to control or reduce this erosion through the planting of grass appear to be successful where the grass has caught. On the east-facing slopes the grass cover is well-developed (Figure 3-26), but on other slopes the cover is still incomplete.

FIGURE 3-26: GRASS COVERING SLOPE OF DYKE OF RESIDUE DISPOSAL AREA.

3.9.1.3 TECTONICS AND FAULTING

3.9.1.3.1 TECTONIC HISTORY

The tectonic history of the Clarendon Plains includes block faulting in the surrounding limestone uplands, producing the half graben in the limestone bedrock underlying the plains (Figure 3-27). This fault activity probably continued during the earlier stages of the formation of the alluvial fan complex. It is likely that the southern Clarendon Plains are experiencing gradual subsidence in recent times.

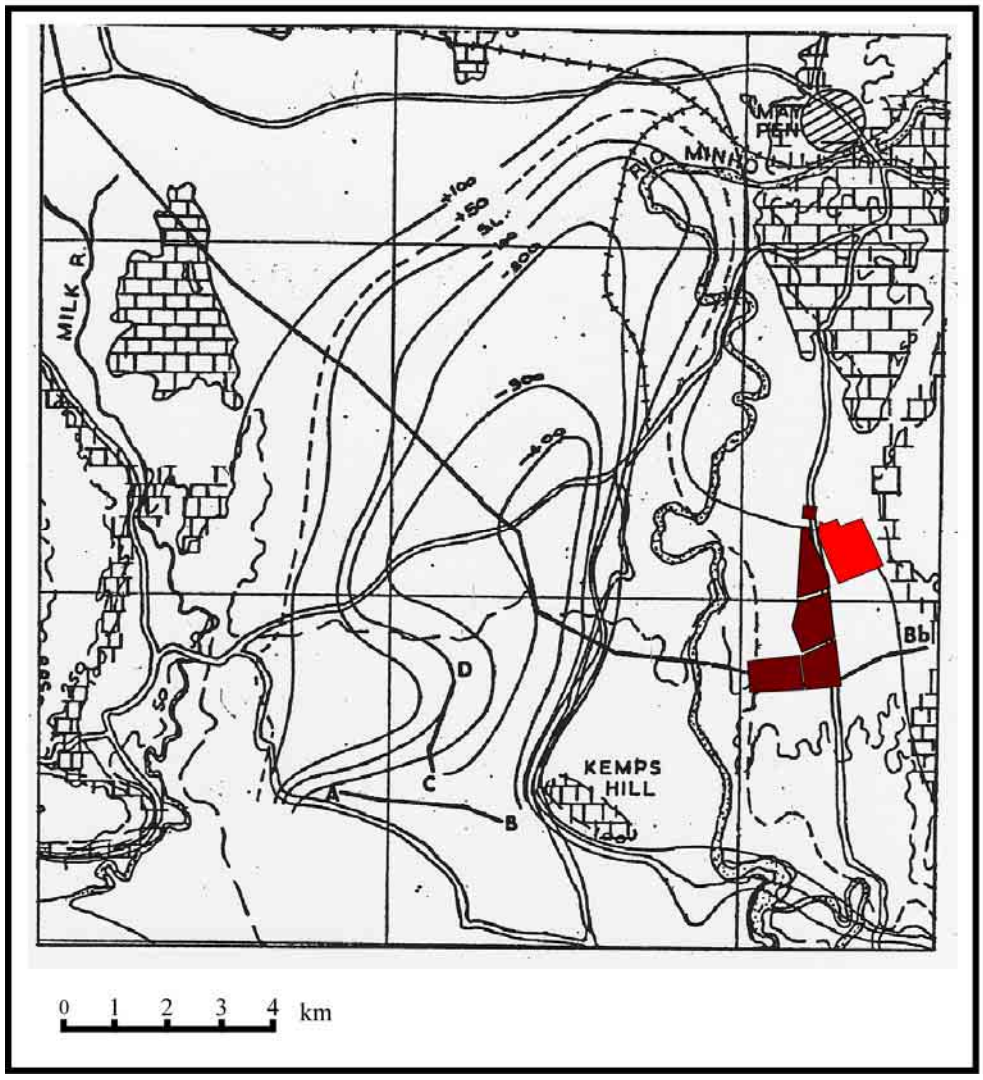


FIGURE 3-27: CONTOUR MAP SHOWING LIMESTONE ELEVATIONS UNDER PLAIN (ELEVATIONS IN FEET ABOVE SEA LEVEL). (SOURCE: CHARLESWORTH, 1980).

3.9.1.3.2 LOCATION OF FAULTS

The distribution of faults on Figure 2 is derived from Geological Sheet #16, May Pen (1974), the earlier 1:250 000 scale geological map of Jamaica (1958) and Charlesworth (1980). The Rio Minho alluvial plain appears largely unaffected by faulting, but as these are superficial deposits it is unlikely that any faults can be identified by surface mapping. Two sets of faults have been mapped within the limestone. One set has a general ENE-WSW trend, while the other set trends roughly N-S. The effects of this faulting and the age relationship with the alluvial plain are uncertain. However, the variability in depth to bedrock (Figure 3-27) suggests the presence of N-S trending faults in the bedrock which have controlled the thickness of alluvial sediments (e.g. the Kemps Hill fault, Figure 3-27; Charlesworth, 1980). These faults may even extend up into the lower part of the alluvial cover, although there is no direct evidence for this. The ENE-WSW trending set is truncated by the alluvium, indicating that the faulting pre-dates the deposition of at least the more recent alluvial material. These faults probably are also continuous beneath the alluvial cover.

The southern part of the alluvial plain, south of Kemps Hill, contains thicker alluvial deposits and this difference in thickness appears to be controlled by the E-W trending South Coast Fault, a well defined feature which extends from Great Pedro Bay in St. Elizabeth a distance of approximately 60 km, through the Brazilletto Mountains in southern Clarendon and beyond. That this fault is still active is strongly suggested by the existence of the radioactive mineral springs that occur at Salt River and Milk River (Zans et al., 1963).

3.9.1.4 SEISMIC ACTIVITY

3.9.1.4.1 LOCAL

Figure 3-28 is a map of Jamaica showing the epicentres for earthquakes that occurred in the period 1998-2001. No local earthquakes of these magnitudes occurred in the vicinity of Hayes, although there is one located on the trace of the buried South Coast Fault.

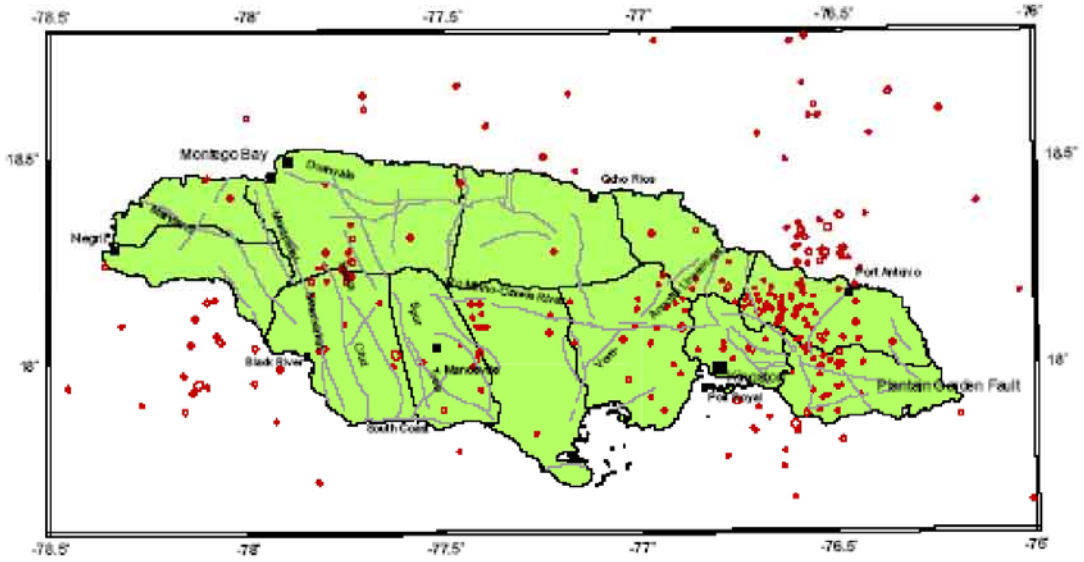


FIGURE 3-28: EPICENTRES OF EARTHQUAKES OCCURRING BETWEEN 1998 AND 2001 LOCATED IN AND AROUND JAMAICA. (SOURCE: THE EARTHQUAKE UNIT).

An investigation of the historical records carried out for an earlier EIA for the Hayes plant and RDAs (Conrad Douglas and Assoc.) of seismic activity in this area has shown that the adverse effects of earthquakes have been experienced there:

"The well-documented 1692 Port Royal earthquake had disastrous effects in the Lower Vere Plains, with modified Mercalli intensities (Appendix D) of MM(X) being experienced in Alley and Salt River, both of which lie at about a 10 km radius from the study area.

The following quote from a newspaper clipping written by the local Rector illustrates: "all brick and stone building were thrown down and water spewed out of the chasms opened in the ground by the earthquake so that even dry gullies ran water". The St. Peter's Anglican Church in Alley built in 1671 was destroyed beyond repair. However, the Halse Hall Great House, where alluvial thicknesses are comparatively low, survived the 1692 earthquake, as well as subsequent ones."

The Great House (now the property of JAMALCO) is situated about 6 km to the north of the JAMALCO alumina plant, and perhaps, more significantly, lies on the well-drained Hayes gravels, well above the water table.

"Subsequent damaging earthquakes are, most notably, those of 1907 and 1957. The 1907 earthquake appears to have caused some damage in the Vere Plains. Intensities of MM(VII) were reported in Alley with incidence of damage to chimneys and buildings (Tomblin & Robson, 1977). The 1957 earthquake had intensities of MM(IV) to MM(V) in the Lower Vere Plains (Robinson *et al.,* 1959). In each 50-year period, starting with 1991 and counting backward for four 50-year cycles, at least one damaging earthquake, of MM(VI) or higher, has occurred in the area. Shepherd (1971) reported that Lower Vere had a frequency of 5-9 damaging earthquakes per century on average.

Compared to the rest of Jamaica, the study area is not in a very active zone. However, the Vere Plain is largely built up of alluvial clays, sand and gravel, and in the presence of ground water, this material will be susceptible to liquefaction in an earthquake of high enough intensity. Thus, the height of the water table will be an important factor in determining the area's earthquake risk.

3.9.1.5 CONCLUSIONS

- The type of limestone does not directly affect the nature of the bauxite deposits. Other factors, such as height above water table, elevation and position on fault blocks may also play a part in ultimate quality of the bauxite.
- There appear to be no impediments from a geological standpoint, to mining bauxite in the proposed area of northern Manchester Parish.
- The mining operation is not likely to encounter problems any different from those experienced in the present mining areas.
- A more complete appraisal will require detailed geological and orebody mapping to determine slopes of mined out orebody faces, extent of brecciated zones in the limestone, etc.

ENVIRONMENTAL IMPACTS

4 ENVIRONMENTAL IMPACTS

Direct negative impacts to the natural resources, and the man made environment in general by the proposed construction of RDA 5 during pre-construction, construction and operational phases have been determined to be minimal.

This determination arises from the fact that the proposed construction represents basically no net change in land use for the area and will not introduce any situation or constituent that will bear negatively on the surrounding community. It is the expressed intention of Jamalco to proceed with decommissioning of completed RDA as soon as possible. This rehabilitation exercise will essentially result in a reduction in the overall exposed surface area of the disposal areas. In fact the existing operations at the existing RDAs have been in place for over 20 years and provide an excellent baseline for assessing the potential impacts of the proposed development.

No cultural heritage monuments, archaeological artefacts or articles of historical significance have been identified within the project area or its surroundings.

The potential environmental impacts which will be occasioned by the construction of RDA 5 will be addressed in terms of the various phases of the proposed project, these are as follows:

4.1 POTENTIAL IMPACTS & PROPOSED MITIGATIVE STEPS

4.1.1 PRE-CONSTRUCTION & CONSTRUCTION ACTIVITIES

4.1.1.1 FUGITIVE EMISSIONS

Potential fugitive dust problems may occur during site clearance activities such as vegetation removal and excavation. Other activities may also contribute to this potential, especially when it is windy, such as:

- Vehicular traffic
- Spillage on access ways
- Stockpiles (overburden)

Other sources of air emissions in the area include:

- Monymusk Sugar Factory
- New Yarmouth Sugar Factory
- Jamaica Public Service Company (power generation)
- Jamaica Energy Partners (power generation)
- Sugar cane field burning
- Coal burning
- Motor vehicles

4.1.1.1.1 MITIGATION

Standard and appropriative mitigative measures inclusive of an irrigation regime and in some cases totally eliminate potential environmental impacts for all phases of the development.

4.1.1.2 NOISE

There may be the potential for noise being generated during pre-construction and construction activities, and as heavy equipment moves around the proposed RDA site.

An audiometric survey was conducted at the proposed RDA boundaries to establish a baseline for the area and to assess the potential for noise impacts on the adjoining communities. This assessment is included as section 3.8.1, of this report.

4.1.1.2.1 MITIGATION

Noise levels from usage of heavy equipments will be minimised by proper maintenance, equipment muffling and regular vehicular monitoring. Background noise levels will also be monitored and compared with existing decibel ratings measured for the baseline conditions. This will be assessed to determine compliance with accepted standards. In the event of non-compliance, corrective action will be taken, such as removal of the equipment from the fleet.

Should it become necessary to conduct blasting activities, the communities will be notified through appropriate signage and communication. Blasting will be performed using high precision blasting techniques, at times least likely to affect and disturb surrounding communities. All rules and regulations governing the use of explosive materials will be adhered to.

4.1.1.3 LOSS OF BIODIVERSITY

There will be no significant impact associated with biodiversity during pre-construction and construction activities. There will be no net change in land use for the project area. The area comprises four existing RDAs. Vegetation loss will be confined to the designated project area and will not involve any identified rare, endemic or endangered species of flora or fauna. The site is a brownsite area.

4.1.1.3.1 MITIGATION

Jamalco has a very proactive and successful program of mine rehabilitation. Jamalco has signed a memorandum of understanding with the Forestry Department to develop revegetation and habitat creation through technologies involving creative conservation. Aspects of this MOU that applies here are:

- During land clearing, utilisation of existing resources on the site must be maximized. These may include timber, buildings and produce.

- If the existing vegetation can assist in the rehabilitation process it should be harvested and redistributed in a timely manner on the areas being rehabilitated.

- Burning as a means to remove vegetation should be used as a last resort and should be considered only after harvesting, habitat and burial options have been considered.

- Land area cleared should be the minimum.

- Topsoil and remaining vegetation debris must be harvested from the entire area to be used and either stored where it can be recovered or utilized immediately on other areas being rehabilitated.

- Whenever topsoil is stored it should be done so for the least possible time to minimize the loss of biological activity and nutrients.

- If there are potentially toxic substances in the overburden they should be handled in such a way as to minimize the impact on the rehabilitation and surrounding areas.

- Clearing of additional vegetation for storage of topsoil and/or overburden should be minimized.

- Finished slope angles in reshaping will depend on aesthetics, final land use, soil characteristics and safety. Reshaped terrain should conform to the natural landscape as much as possible.

- All slopes must be stable. If erosion is likely to occur then erosion control works should be put in place.

- Soil nutrient and pH levels must be adjusted where this is necessary to achieve rehabilitation objectives.

- Topsoil must be replaced as the final soil profile. The thickness and area to which the topsoil is returned must provide the maximum value to the end use of the rehabilitated area.

4.1.1.4 WATER QUALITY

The RDAs have a significant potential for impacting on the groundwater resources of the area. The majority of potable water utilized at the Jamalco facility and those communities around that have piped water comes from wells located in the vicinity of the plant. The methods and type of construction of the new RDA take into consideration the potential for groundwater impacts.

Potential impacts to surface water may arise from increased sediment loads caused by the removal of trees, shrubs and grass during clearing activities. This is not envisaged to be a significant concern as no excavation will have begun during this phase of operation. The receiving body of any significant volumes of surface run-off would be the Rio Minho River to the northwest of the project area. However, as indicated in the hydrology segment of this report, rainfall will have to be in excess of 203mm, just below the 25 year rainfall of 227mm.

Potential impacts on the associated groundwater in the area will be negligible as no situation with the potential to generate toxic or hazardous materials capable of impacting groundwater is anticipated. This is demonstrated by the baseline water quality with the existing RDAs.

4.1.1.4.1 MITIGATION

All boulders removed from the proposed site will be placed along the banks of the river and sand borrow area. This will serve as a means of erosion control.

Precautionary measures will be taken during construction to ensure that there are no major adjustments to the common dike wall shared by RDAs 4 and 2. The civil/structural engineering principles used for the construction of all previous RDAs will facilitate this process and detailed monitoring of the entire construction period will therefore be critical.

Mitigative actions for ground water resources involve lining the RDA with a competent hydraulic barrier of compacted clay with a permeability of 10^{-9} cm/sec.

4.1.1.5 WASTE MANAGEMENT

There will be various types of waste materials that may be generated that must be properly managed. Waste generated may include, hazardous waste (chemicals, lubricants), vegetative matter (land clearing waste), and garbage. Potential impacts stem from the collection, handling and disposal of these waste materials.

4.1.1.5.1 MITIGATION

Jamalco has existing programmes and protocols in place to deal with all types of waste generated there. All waste generated during the construction and commissioning of the RDA will be handled based on these established protocols. The refinery has a landfill facility which includes a sealed area for disposal of certain hazardous materials. All identified waste management impacts can be successfully mitigated.

Solid waste generated during site clearance in the form of stumps, brush roots, trees and miscellaneous concrete structures will be removed to an approved dump site.

4.1.1.6 SEWAGE

During construction, their will be an anticipated 250 temporary employees.

4.1.1.6.1 MITIGATION

Portable chemical toilets will be utilized to meet the demands of this increased capacity. These toilets will be sourced from a reputable licensed company, who will treat and dispose of the contents.

4.1.1.7 VIBRATION

Vibration in and around the RDA will be a potential impact of heavy equipment (bulldozers, excavators, trucks). Depending on the duration and proximity of the mining activity to residents and structures, this impact may be major or minor.

4.1.1.7.1 MITIGATION

No new vibration related impacts are anticipated. If excessive vibration is pre-empted, assessments are done prior to and during the activities to verify levels.

4.1.1.8 AESTHETICS

Aesthetics in the area will be impacted. The removal of vegetation and soils will cause a distinct change in the appearance of the land and land use. This is a major reversible impact, which is addressed in rehabilitation and revitalization of the area when the RDA is decommissioned.

4.1.1.8.1 MITIGATION

Aesthetics in the area will be restored through Jamalco's rehabilitation and revitalization program.

4.1.1.9 ARCHAEOLOGICAL AND HISTORICAL HERITAGE

No new impacts are anticipated at the proposed site.

4.1.1.9.1 MITIGATION

For any archaeological or historical heritage item that may be impacted during pre-construction and construction activities, the Jamaica National Heritage Trust (JNHT) approved guidelines for managing archaeological and historical heritage items discovered during such activities will be utilized by Jamalco. It includes specific methods of operation including the necessary contacts and procedures to follow.

4.1.2 OPERATION ACTIVITIES

4.1.2.1 WATER QUALITY

Potential impacts to the water quality within the project and surrounding areas will be addressed in two segments, as it relates to:

i. Surface water
ii. Groundwater

4.1.2.1.1 IMPACTS ON SURFACE WATER

The potential impacts to surface water quality will be negligible or non-existent, as the operation of the RDA will not contribute to the constituents of surface water runoff. The completed cell will have a designed freeboard capacity suitable for the containment of a typical flood event. In addition overflow contingencies will be in place to eliminate the potential for overflow to ground surface.

4.1.2.1.2 IMPACTS ON GROUNDWATER

Potential impacts on the associated groundwater in the area are possible if a design flaw or liner failure results in the permeating of the clay seal and the release of liquor and caustic compounds into the subsurface soils.

4.1.2.1.3 MITIGATION

The effectiveness of the design of the liner and collection systems together with the quantities of the materials pumped into and extracted from the proposed RDA are integral as mitigative measures to water quality in the operational phase of the project. The baseline established over the past 20 years has shown that the use of a clay hydraulic barrier together with the sandy/gravel layer is effective in the prevention of liner failure which could contribute to groundwater contamination.

The sandy/gravel layer along with the liquid recovery system creates a zero hydrostatic head and lessens the load on the underlying clay zone minimising the potential for liner failure.

Wells located within proximity of the existing RDAs show no sign of direct contamination that can be linked to the disposal areas.

Maintaining the freeboard capacity in the RDAs is crucial as excessive influent levels can lead to overflow and affect water quality. Monitoring the volumetric capacity of the RDA with appropriate level indicators will mitigate the potential for spillages.

RISK ASSESSMENT

5 RISK ASSESSMENT

5.1.1 EMERGENCY RESPONSE PLAN

5.1.1.1 GENERAL OVERVIEW

The following is taken from pertinent sections of Jamalco's Emergency Response Plan.

1. The emergency response procedures included in the following sections are designed as guidelines to follow when a spill, fire, explosion, of other catastrophic event causes a release of oil or other hazardous material to the environment. The procedures presented in this document are intended for use by Jamalco personnel responding to emergency situations at the refinery (including the Residue Disposal Areas). In general, the following types of emergency scenarios are covered by the plan:

- Storage unit leaks and/or rupture,
- Levee failures,
- Leaks/spills during loading/unloading operations,
- Pipeline failures,
- Releases due to catastrophic events (e.g., fires, explosion, earthquakes, floods, and hurricanes).

2. The emergency response procedures are intended to be the primary document that provides the procedures to be followed during a spill event.

3. These procedures will be reviewed annually and amended as needed to address changes or additions to facilities, processes, operations, hazardous substances, and personnel which would adversely impact their effectiveness.

4. Following the occurrence of a spill, release, fire, or explosion that requires implementation of this plan, the Primary Emergency Coordinator should immediately notify the proper regulatory agencies and follow-up with a written Spill Report which will be submitted within the time frame requirements of the applicable regulations.

5.1.2 ALERT PROCEDURES

If a minor leak, spill, release, or fire occurs, the individual discovering the incident should attempt to locate and eliminate the source. If possible, he/she should try to stop or at least contain the release. This can involve closing valves, turning drums upright, activating emergency pumps, using absorbent materials, or extinguishing the fire. These measures should only be undertaken if they can be accomplished without any risk to the individual. If the source is not immediately obvious or if these measures are not effective and the situation is beyond his/her control, then the discoverer should initiate the following emergency procedures using the telephone & radio listing included in this Plan.

5.1.3 FIRST PLANT CONTACT RESPONSIBILITIES

1. Contact the shift supervisor with responsibility over the affected department or area, who has been designated as the First Plant Contact.

2. Pass along the following information:

a) Exact location of the emergency event;
b) Type and description of the emergency;
c) Estimate of the amount of material released, or the size of the fire;
d) Extent of injury or property damage incurred;
e) Extent of the actual and potential environmental damage; and
f) Remedial action taken, if any.

If significant spill conditions exist to the extent that assistance from outside the department is needed, the First Plant Contact should immediately contact the following individuals and communicate the information listed above.

- Security
- Area Superintendent
- Department Manager

It will be Security's responsibility to then contact one of the Emergency Response Coordinators.

5.1.4 EMERGENCY NOTIFICATION PROCEDURES

The Emergency Response Coordinators will provide on-site coordination of safety, emergency response, and remedial measures taken. Responsibilities will also include initial and follow-up notification of spill conditions to government authorities, if required. This information could include the following:

- Time of the spill;
- Identity of material spilled
- Approximate quantity spilled;
- Location and source of spill;
- Cause and circumstances of spill;
- Potential hazards (e.g., fire, explosion, etc.)
- Personal injuries or casualties, if any;
- Corrective action being taken and an appropriate timetable to control, contain, and clean up spill;
- Name(s) and telephone number(s) of individual(s) who discovered and/or reported the spill; and
- Other unique or unusual circumstances.

5.1.5 REQUIRED ALCOA NOTIFICATIONS

The Environmental Affairs Department in the Pittsburgh Office must be notified after every release or emergency response event that requires notification of local government agencies. An Environmental Event/Procedure Report should be completed and mailed to Ms. I. J. Soukup in the Pittsburgh Office.

5.1.6 EMERGENCY RESPONSE PROCEDURES

Based on information obtained from the First Plant Contact, department personnel, and emergency response guidance materials, the Emergency Response Coordinator will develop an initial response plan. At a minimum, the response plan should accomplish the following:

- Determine the classification of the material (e.g., flammable, poison, corrosive or otherwise);

- Determine the level of protection required (e.g., type, level and availability of breathing and skin protection);
- Discuss the hazards (e.g., specific to the material and danger from terrain, ruptures, leaks, falling objects, etc.);
- Direct the staging of response equipment;
- Determine if assistance from agencies outside the facility are needed; and
- Initiate the immediate steps necessary to contain or divert releases away from surface water bodies and other sensitive receptors.

The Emergency Response Coordinator will direct response personnel to obtain the necessary absorbents, barrier materials, or pipe plugging devices that are required to contain the spill and prevent it from reaching surface water bodies or drains that cannot accept the material.

The following information provides general response guidance for spills in specific areas.

1. Spills in Dike Areas

Absorbent material or booms will be placed to contain the spill within the dike area, it possible. If the spilled material is pumpable, portable pumps and/or the suction truck from the Clarification Department will be used to remove as much of the spilled material as possible. The material will be transported to an appropriate disposal site or placed in proper containers for later shipment. All attempts will be made to prevent the released material from entering surface water systems or associated storm drains. Acidic materials may be neutralized with material from the limestone storage pile.

2. Spills in Un-dike Areas

Every attempt will be made to contain the spill as rapidly as possible to prevent runoff from reaching surface water bodies or a storm drain system. If necessary, earthen materials will be used to construct temporary dikes or berms around the spilled material for placement in proper containers. Construction equipment may be used to build diversionary structures to divert or block releases from contaminating soils and/or

surface waters. Acidic materials may be neutralized with material from the limestone storage pile.

3. Spills to On-Site Lakes/Lagoons

Every attempt will be made to limit the amount of spilled materials that could enter lakes/lagoons at Jamalco. In the event that a large spill enters these areas, floating booms will be used to restrict the release to a limited area, if possible. Absorbent material and/or skimming equipment may be used to remove floating materials (e.g. oils and other petroleum products). If the spilled material is one that will mix with water, attempts will be made to isolate the lake/lagoon to keep contaminated material from entering other containment systems. If the released material is compatible with materials already present in lakes/lagoons at the site, those systems may be used for spill containment at the discretion of the Emergency Response Coordinator.

4. Spills on Soil

An attempt will be made to minimize the surficial area of the spill. Earthen dikes or berms will be used to provide containment for the spill. If possible or as practicable, absorbent materials will be placed on the spill area in an attempt to absorb freestanding material from the soil surface. Contaminated soil will be excavated and disposed or containerized for later disposal. Acidic materials may be neutralized in place with limestone.

5. Spills to Receiving Streams

An attempt will be made to contain spilled material at the source of the release, if possible. If the spilled material is moving across land, diversionary dikes, ditches, or berms will be placed using construction equipment to contain or divert the material prior to its reaching surface water bodies or other sensitive receptors.

If the spilled material reaches surface water, absorbent materials or booms will be used to control the material on the water (e.g., petroleum products). If the released material can be controlled, an attempt will be made to remove the material using portable pumps, skimmers, or the suction truck from the Clarification Department. If the spilled material cannot be controlled, other response measures may be taken at the direction of the

Emergency response Coordinator including in situ treatment (e.g., neutralization of acidic materials) and diversion to less sensitive containment areas.

5.2 PREVENTATIVE MEASURES LOADING/UNLOADING OPERATIONS

The following information provides a description of the spill preventative measures employed at loading/unloading operations.

5.2.1 RED MUD LAKE SYSTEM

The Red Mud Lake System incorporates:

- Plant runoff from Storm lake to Mud Lake 1
- Caustic/Mud from the plant to the Mud Lakes
- Cooling water from the Clear lake to the process

To facilitate sound management and operational integrity,

i. Pumping operations are conducted by trained personnel

ii. Liquid levels in the receiving impoundments are monitored

iii. Equipment inspections are performed including pre-pump checks to ensure proper operation, moisture levels in pumps, pump packings, weekly pressure checks and motor control center cleanings

5.2.2 AIR EMISSIONS

The potential sources that would be the likeliest contributors to air emissions are:

- Excavation and stockpiling of soil material during pre-construction and construction activities
- Excavation and stockpiling of sand for use during the construction phase of the project
- Haul road traffic
- Engine emissions from heavy equipment

Practical measures will be utilized during periods of excavation and earth movement to reduce the levels of air emission. Equipment emissions will be controlled through comprehensive maintenance and overhaul programs to ensure that equipment is in sound operational condition.

Dust control on haul roads will be accomplished through applications of calcium chloride to the road surface. Maintenance applications will be made as necessary to maintain the integrity of the roadway. Calcium chloride attracts moisture from the air and binds with the limestone chips used to construct the roads effectively forming a low grade pavement.

5.3 CONTINGENCY PLAN

Preparedness and Prevention

The following information describes the actions and equipment that are available and maintained for immediate use in the event of an emergency release situation.

5.3.1 PLANT COMMUNICATION SYSTEMS

An extensive communications network is maintained at Jamalco for accessing necessary emergency personnel during an emergency situation. Relevant components of the overall communication system are briefly described below.

a) Telephone system - an external telephone system connects each operation of Jamalco including the refinery, Woodside Land Office, Breadnut Valley Mines and Rocky Point Port.

   An internal system extends throughout the refinery and is connected to the Woodside Land Office and Breadnut Valley mines.

b) Radio System - a radio communication system is in place and is an effective method for communicating emergency messages throughout the refinery/chemical plant and especially areas out of reach of the telephone system.

Radio communication equipment includes hand-held units and mobile radio units installed in facility vehicles. During emergencies, limited communications can be maintained on F-1 frequency.

c) HAM radio system - A HAM radio system is in place to provide long-range communication support in the event normal communication systems are inoperable due to an extreme emergency (e.g. hurricane, earthquake, etc.). The HAM radio system is maintained at the Powerhouse Control Room, Building 110.
d) Alarm system - A plant emergency siren is maintained for immediate warning to facility personnel in the event of an emergency. In an emergency situation, security personnel will sound the siren with 2 blasts of 10 seconds each.

5.3.2 OUTSIDE AGENCY SUPPORT

a. May Pen Fire Brigade: The plant Fire Brigade Leader will notify the May Pen Fire Brigade in the event of an emergency and will provide an estimate of additional services needed.
b. May Pen Hospital/Lionel Town Hospital/University of the West Indies Hospital: Jamalco maintains its own medical staff (doctors and nurses) as well as ambulances located at the refinery, Breadnut Valley Mines, and Rocky Point Port.

   The facility will normally transport their own injured personnel to the hospital. However, if conditions warrant, medical staff/security will notify the appropriate hospital in the event of an emergency and will provide an estimate of additional services needed.

5.3.3 EVACUATION PLAN

If it has been determined by an Emergency Response Coordinator that an emergency evacuation is required, employees will be notified via the facility communication system (e.g., emergency siren, telephone system, radio system or directly).

Evacuation from facilities operated by Jamalco, including the refinery, Woodside Land Office, Breadnut Valley Mines and Rocky Point Port will be conducted according to the following procedure:

a. At the sound of the evacuation announcement, work will be stopped in an orderly manner and preparations made to evacuate the area immediately.
b. Upon receiving notification of an impending evacuation, each department supervisor will report to their respective department/area and direct their employees to the nearest sate exit route (if this is feasible). After observing that all employees have evacuated the area, the supervisor will exit the area in question. All facility personnel will relocate to the company parking lot. Upon arrival at the parking lot, the emergency coordinator of his designee (e.g. each department supervisor) will take roll call.

   If it is necessary to relocate at a greater distance from the facility, the decision for the required relocation will be made by the emergency coordinator or his designee.

c. Plant Security and Fire Brigade personnel, when designated by the emergency coordinator to be traffic controllers, will position themselves in proper areas to direct traffic exiting the facility. Traffic controllers may also have the responsibility of escorting emergency vehicles to the incident location.
d. Personnel designated by the emergency coordinator, as necessary, will be expected to search and assure that the area is clear of employees and that all equipment is turned off that is not absolutely necessary.
e. Maintenance personnel will see that utilities are turned off and/or controlled to minimize the potential for secondary fires, explosions, electrical shocks, etc.
f. Once the evacuation is complete, it will be at the discretion of the emergency coordinator as to whether additional tasks are considered safe and/or necessary. Additional tasks could include minor fire fighting assistance, removal or materials or equipment to safe locations, and proper operation/shutdown of plant processes.

5.3.4 EMERGENCY RESPONSE PARTICIPATION IN THE COMMUNITY.

If called upon, Jamalco will donate and use whatever communications and emergency response equipment it has at its disposal to assist during a community wide emergency.

5.3.5 EFFECTS OF EXTERNAL FACTORS ON EMERGENCY RESPONSE PROCEDURES

Certain catastrophic events (e.g., hurricanes, earthquakes, power failures, fires, flood, worker strikes, etc.,) could occur that would limit the ability of Jamalco to implement the emergency response procedures contained in this plan. In this event, Jamalco's Emergency Response Coordinators will quickly assess the situation and make the modifications necessary to ensure the success of response efforts.

The following information is provided to identify the adverse effects associated with catastrophic events that have the potential for occurring at Jamalco:

- Disruption of telephone communication;
- Loss of lighting;
- Loss of computer support affecting process equipment and information services;
- Immediate shutdown of spill control sumps, process equipment, and air control devices;
- Disruption of evacuation procedures;
- Limitations on emergency response and/or vehicle access
- Loss of electrical power
- Loss and/or contamination of water supply (both potable and for fire response)
- Complications resulting from levee failure
- Releases resulting from levee failures

5.4 LANDSLIDE RISK ASSESSMENT

While no detailed assessment of the landslide risk has been carried out in southern Clarendon to date, the landslide inventory map of Jamaica (see Appendix B) shows no record of landslide events for the southern Rio Minho flood plain. The landslide hazard zonation map of Jamaica (see Appendix B) therefore shows this area to be at low risk of landslides (Area No. 1 on the map). The low landslide risk can be attributed to the flat lying nature of the topography, the presence of fairly easily drained alluvial soils, and the relative dry climate.

5.5 LOCAL AND REGIONAL TECTONIC ACTIVITY

An investigation of the historical records of seismic activity in this area has shown that the adverse effects of earthquakes have been experienced. The well-documented 1692 Port Royal earthquake had disastrous effects in the Lower Vere Plains, with modified Mercalli intensities (Appendix B) of MM(X) being experienced in Alley and Salt River, both of which lie at about a 10 km radius from the study area.

The following quote from a newspaper clipping written by the local Rector illustrates: all brick and stone building were thrown down and water spewed out of the chasms opened in the ground by the earthquake so that even dry gullies ran water". The St. Peters Anglican Church in Alley built in 1671 was destroyed beyond repair. However, the Halse Hall Great House, where alluvial thicknesses are comparatively low, survived the 1692 earthquake, as well as subsequent ones. The Great House is situated approximately about 6 km to the north of the JAMALCO alumina plant.

Subsequent damaging earthquakes are, most notably, those of 1907 and 1957. The 1907 earthquake appears to have caused some damage in the Vere Plains. Intensities of MM (VII) were reported in Alley with incidence of damage to chimneys and buildings (Tomblin & Robson, 1977). The 1957 earthquake had intensities of MMCIV) to MM (V) in the Lower Vere Plains (Robinson et al., 1962).

In each 50-year period, starting with 1991 and counting backward for four 50-year cycles, at least one damaging earthquake, i.e. MM (VI) of higher, has occurred in the area. Shepherd (1971) reported that Lower Vere had a frequency of 5-9 damaging earthquakes per century on average.

The map of epicenters in the study area (see Appendix B) represents data gathered between 1981 and 1995 by the national seismograph network. It shows a scatter of small earthquakes around the site. It must be pointed out here that the error in these locations could be up to +1- 5km. The earthquakes shown have magnitudes of between 1.9 and 3.6.

Compared to the rest of Jamaica, the study area is not in a very active zone. However the Vere Plain is largely built up of alluvial clays, sand and gravel, and in the presence of ground water, this material will be susceptible to liquefaction in an earthquake of high

enough intensity. Thus, the height of the water table will be an important factor in determining the area's earthquake risk.

In the borehole data produced by JENTECH, none of the holes encountered the water table during drilling. Maximum depth drilled was 41 feet, where the limestone basement was encountered. This would suggest that the water table in this area is not near the surface, which means that the risk of liquefaction would be reduced. Also, the level of compaction was measured to be >90%, which would again reduce the risk. On the map of Soil and Liquefaction Potential (see Appendix B).

Halse Hall falls within the area designated 'PC' - soils on old alluvium. While there is a high potential for liquefaction along the coastal sections of the Rio Minho alluvial plain, the area inland does not fall into that category. This is due to the fact that the coastal sediments would have a greater percentage of water contained within them, and also the coastal sediments would be more recently deposited and therefore less compacted than those inland.

Figure 9 (Appendix B) gives an indication of regional tectonic activity by displaying earthquake epicenters in relation to major faults, and their correlation with landslide activity. The Halse Hall area is well away from zones of high activity.

SOCIO-ECONOMIC ANALYSIS OF PROJECT IMPACTS

6 SOCIO-ECONOMIC ANALYSIS OF PROJECT IMPACTS

6.1 INTRODUCTION

This report presents the findings of a survey conducted among residents within the radius of influence of the project, in Southern Clarendon between May and June 2004. While this survey was not conducted to solicit views and opinions solely for the construction of RDA 5, it was designed to address the wider issue of the modification of RDA#1, and the Efficiency Upgrade/Expansion of the entire operations which included the Residue Disposal Areas (by Conrad Douglas & Associates Limited - 2004).

Additionally, meetings have been held with community council groups, a major public meeting has been held and other community consultations have taken place in recent times to address various issues related to Jamalco's operations, including the Residue Disposal Areas. Also, a review of the concerns and opinions of the residents from the earlier EIA study for the construction of RDA# 4 completed by Conrad Douglas & Associates Limited (1996) was conducted to revisit the issues at that time.

6.2 SOCIO-ECONOMIC SURVEY

The objective of the survey was to determine the level of knowledge of the population of the existing and proposed operations, to ascertain their views on the perceived or known impacts of the operations as well as to solicit their perceived solutions to existing problems.

6.2.1 METHODOLOGY

The survey was based on a 5 per cent sample of households from the enumeration districts in the study area (as defined by the Statistical Institute of Jamaica) for the 2001 Population Census. The households for administration of the questionnaire were selected at random by the interviewer, within the enumeration districts. The respondent in all instances was the household head.

The information collected through the questionnaire included the following:

1. Personal Characteristics
    - Age and Gender
    - Number of Years Lived in the Community
2. Opinions on the community
    - Factors most preferred
    - Factors least preferred
    - Benefits of large scale development to the community
3. Awareness and Opinions on Existing Bauxite Operations
    - Perceived negative impacts
    - Perceived positive impacts

    Knowledge of and Views on Upgrade Plans as they relate to:
    - Economic Value of the Community
    - Pollution
    - The Local Environment generally
    - The Individual
    - Job Opportunities
4. Water Availability
    - Source of drinking water
    - Perception of water quality
5. Miscellaneous
    - Awareness of community activities by Jamalco
    - Working experience in bauxite industry
    - Receipt of compensation for pollution problems

In most instances the questions allowed for multiple responses. The responses were coded and the data captured. The findings as they relate to the two main areas of the parishes indicated are summarized below. The details of the specific findings related to the communities are presented elsewhere in this report.

6.2.2 THE SURVEY POPULATION

- Issues related to “quality of life and people” were viewed as the best things about the communities; the reasons people liked their communities. An equal percentage of the respondents, 44.4%, stated that what they liked most about

their communities was the "friendly people" and the quietness of the communities. The availability of farmland was the next highest ranked, selected by 15% of respondents.

- The factors, which were reported by most Clarendon respondents as the reason for not liking their community, were unemployment and poor roads. Unemployment was given as the reason by 41.4 per cent of respondents and poor roads by 33.3 per cent.

- More than 7 out of 10 (71.7 per cent) of Clarendon respondents viewed "large scale development as beneficial to the community. Job opportunities and the potential for development of skills were seen as the primary reasons for this view.

- Respondents who did not agree with the statement saw large-scale development as impacting negatively on the environment.

- No direct connection was made between negative impacts and the RDA's, however, opinions related to water quality were mentioned on several occasions.

6.2.3 AWARENESS AND OPINIONS ON EXISTING BAUXITE OPERATIONS

- The majority of respondents (99. per cent) in the vicinity of the RDAs are aware of the existence of bauxite or alumina processing plant operations in the area

- Of these (84.8 per cent) said they personally experience negative impacts

- Dust, soot or gaseous emissions, odour and damage to property are the three factors identified by most of the respondents as the negative impacts. Forty six per cent identified dust etc., while odour and property damage were both identified by 25 per cent and 23 per cent respectively.

- Eight out of ten (83.8 per cent) of the respondents agreed that the bauxite facility has had negative impacts on the people in the community. The reason given by the majority of the respondents is that "the area smells like caustic soda more often than not". Just about a half of the residents (51.5%) gave this response. Almost one fifth of the respondents noted an increase in the frequency of illness

(19%), while 14% of the residents chose "the area has widespread corrosion" and "plants are harder to grow" as reasons.

- Seventy –eight (78.8%) respondents agreed that the bauxite facility has had positive impacts on the people in the community. "Job opportunities" and ironically "environmental conditions" were the reasons given by the majority of the respondents: 51.5 per cent and 16.2 per cent respectively.

6.2.4 KNOWLEDGE AND VIEWS ON UPGRADE PLANS

- Nine out of ten (90.9 per cent) of the Clarendon respondents were aware of the upgrade plans.

- 79 persons felt that the proposed upgrade would affect them personally while 15 respondents felt that it would not affect them. Approximately 4 per cent were not sure while the remaining 1 per cent did not respond.

- While 47.5 per cent of respondents were of the view that the upgrade would have a positive impact on economic value of the community a higher 64.7 per cent saw the effect on job opportunities as positive. Less than 15% of respondents were of the view that there would be no change in relation to job opportunities (13 per cent) or on the economic value (9 per cent) of the community.

- Approximately 39 per cent of respondents were of the view that the proposed upgrade will impact negatively on pollution, 53.5 per cent saw a positive impact while 1 per cent saw no change. 3 per cent said they did not know what the impact on pollution would be.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive as well as negative factors. The increased circulation of dust in the area emerged as the main impact seen by the respondents. More than half (53.5% per cent) of responses identified this as the main impact. 29.3 per cent) of the respondents indicated 'more jobs' as the main impact. More air pollution and noise (19 per cent) and more occurrences of diseases that affect breathing (6 per cent) were the next highest nominated.

- As reasons for the particular answers given, 32.3 per cent stated that 'the present bauxite and mining and processing facilities have caused this already so it can only get worse'. Only 7 respondents felt that more jobs would be available.

6.2.5 AVAILABILITY OF WATER

- (48.5 per cent) of respondents had water piped indoor available to them, while 47.5 per cent had water piped outdoor. The public standpipe was the source for 8.1 person. 3 people are unaccounted for.

- The National Water Commission was the original supplier for all the respondents.

- More than half of the respondents are of the view that the water is not safe to drink (51.5 per cent) while only 29.3% feel that the water is safe. The proportion that does not know or are not sure is 12 per cent.

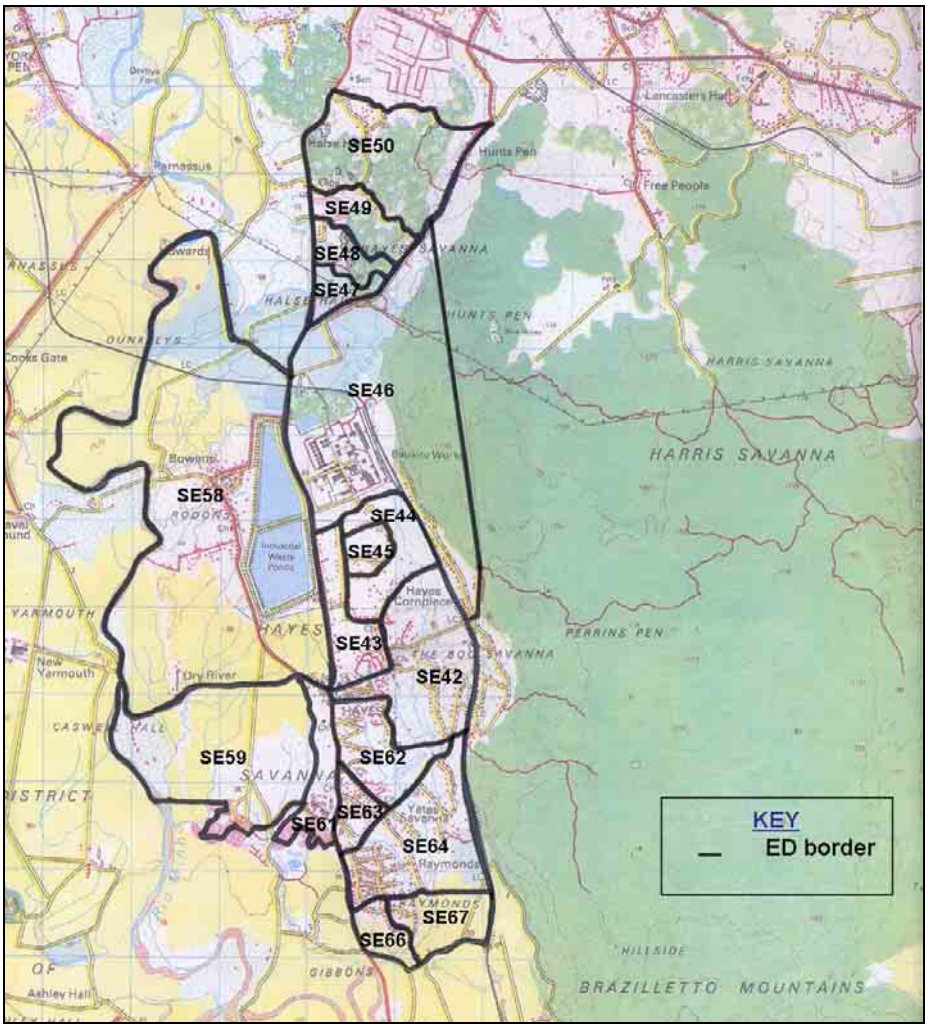
- The main reason given for belief that the water was not safe by 94 per cent of the respondents who stated this view was that the water was affected by bauxite mining and other sources. Sixty nine per cent of the respondents, who felt that the water was safe to drink, felt this way because the National Water Commission tested the water frequently or that the water looked and or smelt clean.

6.2.6 SOUTHERN CLARENDON

6.2.6.1 THE COMMUNITIES

While the selection of the areas for interviewing were based on the enumeration districts as defined by STATIN, the communities as presented in this report were defined in the field by the interviewer and the respondent. Accordingly it is possible for a number of communities to cross Ed boundaries. The list of communities identified appears in Figure 6-1 below.

FIGURE 6-1: Enumeration Districts SURVEYED IN Southern Clarendon



6.2.6.2 DEMOGRAPHIC AND SOCIAL PROFILE

The total population identified for this area in the 2001 census was 24,100. Females were predominant, comprising 50.5 per cent of the total. The women were slightly older than the men with an average age of 27.5 years compared to 27 years for men. In relation to educational attainment approximately 65 per cent of the population 15 years and older had attained a secondary level education, while 7 per cent had attained tertiary level.

There were 5,567 housing units in the area, 90 per cent of which were of the separate-detached type. The main material used in the construction of the housing units was concrete. Average household size was 3.5. While approximately 55 per cent of units were owned, 42.4 per cent were occupied under lease and rent free arrangements.

Eighty-two per cent of the approximately 6100 households had access to piped water. Of this, 9 per cent was receiving the water from a private source. Less tan a half (48 per cent) of households had access to water closets as toilet facilities.

6.2.6.3 FINDING OF THE STUDY FOR THE COMMUNITIES

Due to the small size of the community samples, the analysis will be presented on the basis of the absolute numbers and not on percentages.

6.2.6.3.1 MINERAL HEIGHTS

6.2.6.3.1.1 The Survey Population

A total of 17 respondents were covered in the survey, 10 men and 7 women ranging between 20 and 59 years old. The majority of persons (10) have lived in the community between 11-20 years. Two persons have been residents for more than 20 years.

6.2.6.3.1.2 Main Findings

6.2.6.3.1.2.1 Opinions on the Community

- Twelve persons reported that they liked the community because of the friendly people and because it was quiet and 4 persons liked it because of the clean environment.
- Crime and Violence (5) Unemployment (4) and poor roads (3) were the main reasons given for not liking the community.
- Fifteen of the 17 residents interviewed viewed “large scale development as beneficial to the community”. Job opportunities and the potential for development of skills were seen as the primary reasons for this view

6.2.6.3.1.2.2 Awareness and Opinions on Existing Bauxite Operations

- Sixteen (16) persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 12 of them said that they had not experienced any negative impacts from the operations.

- The 4 who reported that the operations had impacted negatively on them identified dust, soot and gaseous emissions and odour as the factors affecting them.

- Four persons agreed that the bauxite facility has had negative impacts on the people in the community. The reasons given were that, the area smells like caustic soda more often than not (2); the area has widespread corrosion (1); and you get sick more often (1).

- All 17 respondents agreed that the bauxite facility has had positive impacts on the people in the community because of the job opportunities (16); educational and social benefits (2); and improved community relations (1).

6.2.6.3.1.2.3 Knowledge and Views on Upgrade Plans

- Fifteen of the 17 persons were aware of the upgrade plans, 10 thought the impact on the economic value of the community would be positive and 14 saw the impact on job opportunities as positive.

- With regard to the impact on pollution, 9 persons saw it as negative, 5 as positive, 1 saw no change and 2 did not know.

- While 11 persons felt the upgrade will *not* affect them personally, 3 felt it would and 3 were not sure. One person did not respond.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive as well as negative factors. The prospects of job opportunities emerged as the main impact seen by 10 of the respondents. More dust circulating in the area (5); loss of income (2); more air pollution and noise (1); less air pollution and noise (1); and more diseases affecting breathing (1); were the other reasons given.

- As reasons for the particular answers given, 11 stated that more jobs would be available. Presumably in relation to the circulation of dust and the existence of more pollution and noise, 3 respondents felt that the present bauxite and mining and processing facilities have caused this already so it can only get worse and this is something common to all bauxite operations (1). One respondent was of the opinion that the upgrade will add new equipment that will be cleaner to operate.

6.2.6.3.1.2.4 Availability of Water

- All 17 respondents had water piped indoor available to them with The National Water Commission as the original supplier

- Fourteen (14) persons were of the view that the water is safe to drink because it is tested frequently by the NWC (13) and it looks and smells clean (1).

6.2.6.3.1.2.5 Awareness and Solutions

- Only 4 of the 17 respondents stated that they had ever voiced an opinion on the pollution problem.

- Eight (8) persons said that they were satisfied with efforts to deal with the health problems in the community.

- No one had ever received compensation from Jamalco

- Four (4) persons reported that they or members of their household had worked in the bauxite industry.

- Six (6) of the 17 respondents indicated an awareness of programs or activities initiated by JAMALCO.

- While 7 persons said they did not know or were unsure of what should be done about the pollution problem, 5 responses suggested that the bauxite emissions should be controlled/ reduced and the air filtered, while 2 responses recommended a plant upgrade.

- In relation to the health problems, the responses were as follows; provide free/partially funded healthcare (2); build/expand clinic (1); and compensation for residents/discomfort allowance (1); upgrade plant (2).

- Eleven (11) persons did not know or did not respond.

6.2.6.3.2 BOWENS

6.2.6.3.2.1 THE SURVEY POPULATION

A total of 16 respondents were covered in the survey, 7 men and 9 women. Fourteen persons were between the ages of 20 and 59 years and 2 men were 60 years and over. The majority of persons (11) have lived in the community for more than 10 years, with 5, more than 20 years.

6.2.6.3.2.2 MAIN FINDINGS

6.2.6.3.2.2.1 Opinions on the Community

- Eight persons reported that they liked the community because it is quiet, 4 because of the friendly people and 3 because of the availability of farmland.

- Unemployment (6), poor roads (4) and the dirty environment (2) were the main reasons given for not liking the community.

- Ten of the 16 residents interviewed saw “large scale development as beneficial to the community”. Job opportunities (8) were seen as the primary reason for this view.

6.2.6.3.2.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 16 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and 14 of them said that they had experienced negative impacts from the operations.

- Odour (6), dust, soot and gaseous emissions (6) and damage to property (5) were the main factors identified.

- All but two persons agreed that the bauxite facility has had negative impacts on the people in the community. The reasons given were that, the area smells like caustic soda more often than not (8); you get sick more often (3); and plants are harder to grow (2).

- Twelve of the 16 respondents agreed that the bauxite facility has had positive impacts on the people in the community because of the job opportunities (7) and the environmental conditions (4).

6.2.6.3.2.2.3 Knowledge and Views on Upgrade Plans

- Fifteen of the 16 persons were aware of the upgrade plans, 5 thought there would be no change in the economic value of the community impact on the economic value of the community, while there were as many responses (4) for a positive impact as for a negative impact. In relation to job opportunities, while 7 persons saw a positive effect, 5 persons saw no change, 2 saw a negative effect and 2 did not know.

- With regard to the impact on pollution, 10 persons saw it as positive, 5 as negative, and 1 did not know.

- While 14 persons felt the upgrade will affect them personally, 2 felt it would not.

- The responses to the question on the main impact overall of the proposed upgrade suggested negative factors. More dust circulating in the area (8) and more air pollution and noise (6) were the main reasons given.

- As reasons for the particular answers given there were 13 responses stating that the present bauxite and mining and processing facilities have caused this already so it can only get worse.

6.2.6.3.2.2.4 Availability of Water

- Fourteen respondents had water piped indoor available to them and 2 had outdoor pipe. The National Water Commission was the original supplier

- Only 1 person was of the view that the water is safe to drink. Nine said it was not safe and 5 were not sure. Seven persons gave the reason for doubting the safety as 'bauxite mining affects the water'.

6.2.6.3.2.2.5 Awareness and Solutions

- Thirteen of the 16 persons said they had voiced their opinion on the health and pollution problems in the community
- Thirteen (13) persons said that they were not satisfied with efforts to deal with the health problems in the community.
- Six of the 16 respondents had received compensation in the past.
- Three (3) persons reported that they or members of their household had worked in the bauxite industry.
- Six (6) of the 16 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- Regarding advice on solutions to the pollution problem, 5 persons suggested a relocation of the plant and 4 recommended control and reduction of bauxite emissions.
- In relation to the health problems, the responses were as follows; provide free/partially funded healthcare (5); build/expand clinic (2); and compensation for residents/discomfort allowance (4).

6.2.6.3.3 RAYMONDS

6.2.6.3.3.1 THE SURVEY POPULATION

A total of 17 respondents were covered in the survey, 8 men and 9 women. All except one man ranged in age between 20 and 59 years old. The majority of persons (9) have lived in the community between 11-20 years and 7 persons have been residents for more than 20 years.

6.2.6.3.3.2 MAIN FINDINGS

6.2.6.3.3.2.1 Opinions on the Community

- Twelve persons reported that they liked the community because of the friendly people and because it was quiet and 4 persons liked it because of the availability of farmland.

- Poor roads (6); unemployment (5); crime and violence (3); the dirty environment (2); and unfriendly people (1); were the main reasons given for not liking the community.

- Ten of the 17 residents interviewed saw "large scale development as beneficial to the community". Job opportunities (8) were the primary reason for this view. One person indicated the opportunity for skills development and one person although seeing the benefits of large-scale development, thought that it would affect environmental quality, negatively.

6.2.6.3.3.2.2 *Awareness and Opinions on Existing Bauxite Operations*

- All 17 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and all of them said that they had experienced negative impacts from the operations.

- Dust, soot and gaseous emissions (10); damage to property (5); and odour (2) were the main factors identified.

- All 17 also agreed that the bauxite operations have had negative impacts on the people in the community. The reasons given were that, the area smells like caustic soda more often than not (12); the area has widespread corrosion (1); you get sick more often (3); and plants are harder to grow (1).

- While 11 respondents agreed that the bauxite facility has had positive impacts on the people in the community, 6 said it did not. Job opportunities (8) and environmental conditions (3) were cited as the reasons.

6.2.6.3.3.2.3 *Knowledge and Views on Upgrade Plans*

- Fifteen of the 17 persons were aware of the upgrade plans. Ten persons thought the impact on the economic value of the community would be positive and 14 saw the impact on job opportunities as positive.

- With regard to the impact on pollution, 12 persons saw it as positive, 5 as negative.

- Most persons (16) felt the upgrade will affect them personally.

- The responses to the question on the main impact overall of the proposed upgrade suggested positive as well as negative factors. Most responses (8) related to 'more dust circulating in the area' while 7 responses indicated t job opportunities as the main impact. Loss of income (1) more air pollution and noise (6) were the other reasons given.

- As reasons for the particular answers given 10 stated that the present bauxite and mining and processing facilities have caused this already so it can only get worse. There were 7 responses stating that more jobs would be available.

6.2.6.3.3.2.4 Availability of Water

- The majority of respondents (14) received water from outdoor pipes. Only 2 had indoor pipes and 1 used a public standpipe. The National Water Commission was identified as the original supplier.

- Fourteen (14) persons were of the view that the water *was not* safe and 3 were not sure. The reason given by the 14 persons was that bauxite mining affects drinking water.

6.2.6.3.3.2.5 Awareness and Solutions

- All but one person indicated that they had voiced their opinion regarding health and pollution problems.

- Sixteen (16) of the 17 persons said that they were not satisfied with efforts to deal with the health problems in the community.
- Ten (10) persons had received compensation in the past.
- Four (4) persons reported that they or members of their household had worked in the bauxite industry.
- Only 3 of the 17 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- Thirteen (13) persons suggested an upgrade of the bauxite plant as a solution to the pollution problem. Two (2) responses suggested that the bauxite emissions should be controlled/reduced and the air filtered.
- In relation to the health problems, the main responses were as follows; provide free/partially-funded healthcare (6); relocate JAMALCO farther away (5); and compensation for residents/discomfort allowance (2).

6.2.6.3.4 SAVANNAH

6.2.6.3.4.1 The Survey Population

A total of 15 respondents were covered in the survey, 8 men and 7 women. Twelve persons were between the ages of 20 and 59 years and 3 men were 60 years and over. The majority of persons (9) have lived in the community for more than 20 years. Six persons have been resident between 11 and twenty years.

6.2.6.3.4.2 MAIN FINDINGS

6.2.6.3.4.2.1 Opinions on the Community

- Six persons reported that they liked the community because it is quiet, 4 because of the friendly people and 3 because of the availability of farmland.
- Unemployment (9) and poor roads (5) were the main reasons given for not liking the community.

- Ten of the 15 residents interviewed saw "large scale development as beneficial to the community". Job opportunities (7) were seen as the primary reason for this view.

6.2.6.3.4.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 15 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and all of them said that they had experienced negative impacts from the operations.

- Odour (5); dust, soot and gaseous emissions (5) and damage to property (5) were the factors identified.

- Fourteen persons agreed that the bauxite facility has had negative impacts on the people in the community. The reasons given were that, the area smells like caustic soda more often than not (7); and you get sick more often (3) ; the area has widespread corrosion (2) and plants are harder to grow.

- Thirteen of the fifteen respondents agreed that the bauxite facility has had positive impacts on the people in the community because of the job opportunities (5); environmental conditions (5); improved community relations (2) and educational and social benefits (1).

6.2.6.3.4.2.3 Knowledge and Views on Upgrade Plans

- Fourteen of the 15 persons were aware of the upgrade plans but not all thought the impact on the economic value of the community would be positive. While 6 persons thought the impact would be positive, 5 expressed the view that it would be negative, 1 thought there would be no change and 2 did not know. Ten of the respondents felt however that the impact on job opportunities would be positive.

- With regard to the impact on pollution, 10 persons saw it as positive and 5 as negative.

- Most persons (14) felt the upgrade will affect them personally.

- The responses to the question on the main impact overall of the proposed upgrade suggested more negative than positive factors. More dust circulating in the area (8) and more diseases affecting breathing (5) were the main reasons given. There were 4 responses for more job opportunities.

- As reasons for the particular answers given 12 respondents felt that the present bauxite and mining and processing facilities have caused this already so it can only get worse and this is something common to all bauxite operations (2).

6.2.6.3.4.2.4 Availability of Water

- Most persons (11) used outdoor pipes, and 4 had water piped indoors. The National Water Commission was the original supplier

- The respondents were equally divided on the question of the water safety; six persons were of the view that the water is safe to drink, 5 felt it was not safe and 4 were not sure. The water is tested frequently by the NWC (5) and it looks and smells clean (1); while bauxite mining affects the drinking water (4) were the responses regarding reasons for the opinions.

6.2.6.3.4.2.5 Awareness and Solutions

- Ten of the 15 persons said that they had voiced their opinion about the pollution and health problems in the past.

- All 15 respondents said that they were not satisfied with efforts to deal with the health problems in the community.

- Fourteen persons had received compensation in the past.

- Five (5) persons reported that they or members of their household had worked in the bauxite industry.

- Only 4 of the 15 respondents indicated an awareness of programs or activities initiated by JAMALCO.

- Suggestions regarding the solutions to the problem of pollution were as follows: relocate the plant (6); upgrade the plant and control/reduce bauxite air emissions.

- In relation to the health problems, the main responses was provide free/partially-funded healthcare (6).

6.2.6.3.5 HAYES CORNPIECE

6.2.6.3.5.1 The Survey Population

A total of 30 respondents were covered in the survey, 15 men and 15 women. The majority of persons (25) were between the ages of 20 and 49 years and 23 persons have lived in the community for more than 20 years.

6.2.6.3.5.2 Main Findings

6.2.6.3.5.2.1 Opinions on the Community

- Friendly people (11), quiet (5) and availability of farmland (4) were given as the main reasons for liking the community.

- Poor roads (14); unemployment (14); and the dirty environment (6) were the main reasons given for not liking the community.

- Twenty four of the 30 residents interviewed saw “large scale development as beneficial to the community”. Job opportunities (20) were seen as the primary reason for this view.

6.2.6.3.5.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 30 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and all of them said that they had experienced negative impacts from the operations.

- Dust, soot and gaseous emissions (25); noise (12) and odour (9) and damage to property (8) were the main factors identified.

- All persons agreed that the bauxite facility has had negative impacts on the people in the community. The reasons given were that, the area smells like caustic soda more often than not (22); too much noise (9); you get sick more often (9); plants are harder to grow (9) and area has widespread corrosion (6);

- The majority of respondents (21) agreed that the bauxite facility has had positive impacts on the people in the community mainly because of the job opportunities (15); educational and social benefits (5).

6.2.6.3.5.2.3 Knowledge and Views on Upgrade Plans

- The majority of respondents (27) were aware of the upgrade plans. Seventeen (17) thought there would be positive effects on the economic value of the community. In relation to job opportunities, while 20 persons saw a positive effect, while 5 persons saw no change.

- With regard to the impact on pollution, 15 persons saw it as negative while 12 persons saw it as positive.

- Twenty eight (28) persons felt the upgrade will affect them personally, 2 felt it would not.

- The responses to the question on the main impact overall of the proposed upgrade suggested negative factors. More dust circulating in the area (19) and more air pollution and noise (6) were the main negative reasons given while 8 responses indicated more jobs.

- As reasons for the particular answers given there were 23 responses stating that the present bauxite and mining and processing facilities have caused this already so it can only get worse.

6.2.6.3.5.2.4 Availability of Water

- The majority of respondents (20) had outdoor piped water available to them, 7 had indoor pipe with The National Water Commission being the original supplier

- Only 8 persons were of the view that the water is safe to drink. Nineteen said it was not safe because bauxite mining affects the water.

6.2.6.3.5.2.5 Awareness and Solutions

- Twenty three of the 30 persons said they had voiced their opinion on the health and pollution problems in the community
- All 30 persons said that they were not satisfied with efforts to deal with the health problems in the community.
- Twenty two (22) of the 30 respondents had received compensation in the past.
- Twenty one (21) persons reported that they or members of their household had worked in the bauxite industry.
- Twenty respondents indicated an awareness of programs or activities initiated by JAMALCO.
- Regarding advice on solutions to the pollution problem, 14 persons suggested a relocation of the residents and 6 recommended the relocation of the plant.
- In relation to the health problems, the responses were as follows; provide free/partially funded healthcare (14) and compensation for residents/discomfort allowance (5).

6.2.6.3.6 HAYES NEWTOWN

6.2.6.3.6.1 The Survey Population

A total of 4 respondents were covered in the survey, 1 man and 3 women all between the ages of 20 and 59 years. All 4 had lived in the community for between 11 and 20 years.

6.2.6.3.6.2 Main Findings

6.2.6.3.6.2.1 Opinions on the Community

- No one reason stood out as the main one for liking the community as each person had a different response; friendly people, availability of farmland, quiet and no crime and violence.
- Unemployment (3), poor roads (1) and more development needed (2) were given as reasons for not liking the community.
- The 4 respondents were divided equally on the issue of the benefits of large-scale development as 2 said it was beneficial while said it was not. The potential for skills development and the negative effect on the environment were given as the reasons for the respective answers.

6.2.6.3.6.2.2 Awareness and Opinions on Existing Bauxite Operations

- All 4 persons said that they were aware of the existence of bauxite or alumina processing plant operations in the area and all of them said that they had experienced negative impacts from the operations.
- Odour (3) was the main factor identified.
- All agreed that the bauxite facility has had negative impacts on the people in the community, because the area had widespread corrosion.
- The 4 persons also agreed that the bauxite facility has had positive impacts on the people in the community and interestingly identified environmental conditions as the reason.

6.2.6.3.6.2.3 Knowledge and Views on Upgrade Plans

- All 4 persons were aware of the upgrade plans and were not very positive about the impact on the economic value of the community. Two thought this would be negative and 2 thought there would be no change. In relation to job opportunities 3 persons thought there would be no change.

- All 4 persons did however see a positive effect on pollution.
- The 4 persons felt the upgrade will affect them personally as more dust would be circulating in the area. This was because this was common to all bauxite operations.

6.2.6.3.6.2.4 Availability of Water

- All 4 respondents had water piped indoor available to them .The National Water Commission was the original supplier
- No one was of the view that the water is safe to drink because bauxite mining affects drinking water.

6.2.6.3.6.2.5 Awareness and Solutions

- All 4 persons said they had voiced their opinion on the health and pollution problems in the community and all said that they were not satisfied with efforts to deal with the health problems in the community.
- Two of the 4 respondents had received compensation in the past.
- Two (2) persons reported that they or members of their household had worked in the bauxite industry.
- Two of the 4 respondents indicated an awareness of programs or activities initiated by JAMALCO.
- Regarding advice on solutions to the pollution problem, 1 person suggested an upgrade of the plant and 1 recommended control and reduction of bauxite emissions.

In relation to the health problems there were 3 responses recommending a relocation of people and 2 suggesting community meetings

IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

7 IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

The following is a summary of the alternatives considered in this phase of Jamalco's Residue Management Plan:

- No Action
- Expand lifespan of existing RDAs by elevating perimeter dike walls
- Dredge existing RDAs and process residue through paste thickener
- Construct unsealed Red Mud Lakes in remote areas of the community
- Disposal of Red Mud at sea
- Reduce Production
- Construction of RDA 5 incorporating a combination of thickened tailings disposal and dry stacking technology. (selected alternative)

7.1 ANALYSIS OF ALTERNATIVES

7.1.1 NO ACTION ALTERNATIVE

The no action alternative would not be practical at this time as Jamalco has very limited capacity remaining at this time and does not foresee going beyond November of 2006 before additional residue storage will become an absolute necessity. When factors related to permitting, time of construction and time for proper commissioning of a quality residue disposal facility are considered it is absolutely necessary that decisions are made now and solutions are implemented.

Jamalco has had to implement a series of interim capacity building exercises over the last few years to provide a buffer while plans, designs and permission is sought for the construction of a new RDA. These included the raising of the dike walls on RDAs 3,and 4 and the construction of a Step-in-Dike within RDA 1 to test the combined technologies of thickened tailings disposal and dry stacking.

The No Action Alternative would result in the near term shut down of the Jamalco refinery, the abandonment of plans for upgrade and expansion and a serious economic blow to the surrounding communities and Jamaica at large.

7.1.2 INCREASE LIFESPAN OF EXISTING RDAS BY ELEVATING DIKE WALLS

This is a possible alternative, however, the dike walls on the RDAs 3 & 4 have been raised previously resulting in additional capacity but also increased the negative aesthetic impact on the surrounding communities. To further increase the height may not be the best long term solution.

7.1.3 DREDGE EXISTING RDAS AND PROCESS THROUGH PASTE THICKENER

This is a possible alternative that is being contemplated. However, this would only result in a small increase in capacity across the existing RDAs when compared to what is required and what could be gained from a new facility. Jamalco is always seeking to maximise the potential of the existing red mud disposal infrastructure, so this alternative will be seriously considered, however, it would not meet the needs of a plant that is seeking to increase it production output from 1.2 to 2.8 Mtpy. This is not the preferred alternative.

7.1.4 CONSTRUCT UNSEALED RED MUD LAKE IN REMOTE AREA OF COMMUNITY

Possible alternative that has been used extensively by other bauxite-alumina companies, but never by Jamalco. Jamalco is a zero discharge facility and this alternative would represent a step backward for the company as the technology they have pioneered in Jamaica, sealed impoundments is far superior in the protection of environmental and natural resources and by extension the well being of people. The potential negative impacts on groundwater are far reaching in unsealed impoundments. This is not a preferred alternative.

7.1.5 DISPOSAL AT SEA

Impractical alternative that is practiced in other countries. Jamaica relies heavily on the bounty and beauty of its coastal resources. Even if piped into deep water, it is uncertain and risky and provides no guarantees that near shore resources will not ultimately be impacted. The potential for environmental and socio-economic damage is significant and this alternative should not be considered further.

7.1.6 REDUCE PRODUCTION

Implementation of this alternative would result in increased lifespan of existing residue disposal solutions since less red mud would be produced. However, the world market for alumina is at its highest levels ever and Jamalco and its partner the Government of Jamaica want to be able to capitalize on this reality. In times when sales are slow and prices are sluggish, both Jamalco and the Government have a responsibility to meet obligations, provide employment and service the communities of the area. It is therefore not unreasonable for them to want to capitalize on the current growth of the industry. While this alternative is reasonable it is not the preferred alternative.

7.1.7 SITE RDA 5 AS PROPOSED

This is the preferred alternative.

Construction of RDA 5 using the technologies, designs and construction protocols that have been tried and tested since 1972 to present appears to be the least disruptive, most environmentally friendly and cost effective means of establishing the volume of storage required for Jamalco's upgrade and expansion of operations. The inclusion of thickened tailings, dry stacking technology and the now familiar under drain system for leachate collection to the designs of RDA 5 will allow the facility to hold more residue in a more environmentally friendly manner and enhance the ability of the area to be rehabilitated in a shorter timeframe due to the compacted nature of the residue, high shear strength and load bearing capacity. Interim steps implemented for additional capacity in existing RDAs will provide just enough time for a project of the scope of RDA 5 to be constructed and keep the refinery operating at full potential throughout.

It is noteworthy that of all the alternatives stated above, sealed impoundment disposal of red mud residue using thickened tailings and dry stacking technology is the most appropriate and acceptable method to meet Jamalco's operating procedures and long term goals.

ENVIRONMENTAL MONITORING AND MANAGEMENT PLAN

8 ENVIRONMENTAL MONITORING AND MANAGEMENT PLAN

8.1 MONITORING PROGRAMME

In keeping with its Environmental Health and Safety policies as well as the legislation and regulations of the Government of Jamaica, Jamalco has an extensive Environmental Monitoring Programme which is carried out on all aspects of its operations.

In respect of Section 17 of the NRCA Act of 1991 the company is required to and submits the results of its Monitoring Programme to NEPA on a quarterly basis.

Among the parameters reported to NEPA are:

- raw materials used
- water quality
- effluent quality
- hazardous materials used
- water consumption
- fuel specifications
- materials and chemicals consumption. This category includes:
    - solvents
    - flocculants
    - oils and lubricants
    - acids
    - refrigerants

Jamalco also provides monthly monitoring and reporting to the Jamaica Bauxite Institute (JBI). In addition to the above named, ongoing monitoring activities, Jamalco will implement a monitoring programme during this brownsite efficiency upgrade, which will cover the pre-construction, construction and operations phases of the efficiency upgrade at the mines, the refinery the port and the transportation corridors.

These will be based on the potential impacts identified in the impact identification and impact mitigation actions documented in those sections of this report.

The objective is to insure that all potential impacts and the appropriate mitigation actions are taken.

Monitoring will be done at regular intervals as follows:

1. The conditions of the sites and transportation corridors will again be inspected and recorded two weeks before construction start-up

2. At start-up of construction all activities will be monitored every two weeks for the first three months.

3. Monitoring will take every month from month four to month six.

4. Monitoring will take place quarterly until completion of construction i.e. from month seven to twenty four.

5. Monitoring will be on a monthly basis for three months during commissioning and start-up.

Monitoring reports will be prepared and submitted to NEPA for each monitoring interval for 1 to 5 above.

8.2 ENVIRONMENTAL MANAGEMENT

Jamalco is an ISO 14001 and ISO 9000 certified facility. Jamalco's ISO 14001 Certification was issued by Det Norske Veritas (DNV) in November of 2002 and remains valid until November 2005. The associated Environmental Management System (EMS) is accredited by ANSI RAB.

The EMS covers Jamalco's operations and includes activities associated with the railway transportation system, the bauxite alumina refinery, plant waste storage and disposal sites and the port at Rocky Point.

In keeping with the mandates of its ISO 9000 quality certification, Jamalco abides by their Quality Policy, which states:

Jamalco is committed to being "The Alumina Supplier of Choice"

- "Jamalco will relentlessly pursue continual improvement in everything we do to:
- Consistently provide product that meets customer and other applicable requirements for quality
- Enhance customer satisfaction by consistently meeting and exceeding their expectations
- Be cost effective and remains competitive in the global market
- Operate in a safe and environmentally responsible manner"
- Excellence Through Quality

Jamalco has a highly qualified technical, administrative and support staff within its Environmental Management Department, many trained to the tertiary level. All employees within the Department report to the Manager, Environmental, Health & Safety, a senior manager in the company who in turn reports directly to the Managing Director.

All aspects of Jamalco's operations have an environmental management, health and safety component. Environmental Standard Operating Procedures, guidelines and instruction have been developed by Jamalco to govern operations in all areas. As a result, all technical and support staff have a responsibility to insure that they operate in a safe and responsible manner regardless of the task being undertaken.

Many aspects of environmental management at the facilities are monitored through the use of checklists, periodic reporting and internal audits. These provide timely indications as to the effectiveness of the procedures and provide indications as to the need for changes where applicable. The monitoring and checks also inform process operations and controls.

8.2.1 TRAINING

Jamalco has a commitment to the improvement and advancement of all its employees. A major component of this commitment is the provision and facilitation of training for employees at all levels.

Specific to environmental management, Jamalco provides training in the following areas, which are designed to keep relevant employees and contractors informed and ensures competence in performing their duties. The training program achieves the following:

- Conformance with Jamalco's EH&S policy
- Identifies significant actual and potential impacts of their work
- Defines associated benefits of improved personal performance
- Identifies the roles and responsibilities in achieving conformance with the EMS
- Relays proper environmental operating procedures for managing environmental related aspects of their duties
- Reinforces Jamalco's policy that only properly trained and experienced individuals are allowed to work unsupervised

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ENVIRONMENTAL WASTE AND OCCUPATIONAL HEALTH AND SAFETY

9 ENVIRONMENTAL WASTE AND OCCUPATIONAL HEALTH AND SAFETY

9.1 RISK ASSESSMENT AND HUMAN HEALTH RISK

Four main categories of risk have been identified, which must be avoided or minimized in the efficiency upgrade for all aspects of the project. These are:

1. Natural Hazards
2. Manmade Hazards
3. Accidents
4. Structural Failure

The associated risks are described below and actions suggested for avoidance, minimization, prevention and solution are illustrated in the table below:

TABLE 9-1: Risks and their Preventative Actions

Category	Risk	Source	Prevention	Solution
Natural Hazards	Hurricane	Nature	None	Implement 72 hour shutdown procedure; coordinate with ODPEM
	Earthquake	Nature	None	Plant and facilities designed to withstand earthquakes greater than 7.0 on the Richter Scale
	Flood	Rainfall		Proper design, construction and maintenance
	Lightning	Nature	None	Lightning arrestors
Manmade Hazards	Fire	Various (electrical, mechanical, accidental)	Proper maintenance and monitoring	Employ state of the art fire fighting systems to control and extinguish
	Explosion	Various (explosive environment, human error)	Proper maintenance, instrumentation and fail-safe systems	Continual training, audits, testing and monitoring
	Equipment Failure	Various	Proper maintenance, instrumentation and fail-safe systems	Continual training, inspection, audits, testing and monitoring
Accidents	Electrocution	Electrical contact	Training, education	Lock-out, tag-out procedures
	Contravening Safety Procedures	Ignorance, negligence	Training, supervision and audits	Educative discipline
	Falls	Structures	Training, education, with updates	Provision and use of proper equipment
	Suffocation	Confined/poorly ventilated Space	Training, following standard procedures	Adequate ventilation, buddy system, signage
	Spills	Vessels, pipeline	Implementation of Jamalco's spill management procedures	Implementation of Jamalco's spill management procedures
Structural Failure	Dike Failure	RDAs	Proper design and engineering	Inspection, corrective actions
	Impoundment Liner	RDAs	Proper design and engineering	Inspection, corrective actions

9.2 OCCUPATIONAL HEALTH AND SAFETY

9.2.1 JAMALCO'S OH&S POLICY

Jamalco's OH&S policy is based on the worldwide policy used by Alcoa at all their operations and as such is often more stringent in many respects than local OH&S requirements. All activities must be conducted in a safe manner with proper regard for the health of all concerned. No worker will be required to work in any area and to do any activity without adequate provisions being made to ensure that the health and safety of that worker is not compromised.

Jamalco has an organized, documented set of Standard Operating Procedures which govern employees' actions as they perform tasks at the facility. These procedures provide definitions of unfamiliar terms, outlines required safety equipment necessary to undertake the activity, provides direction and instruction on proper handling and management of associated waste streams and record keeping guidelines. This approach to worker safety is universal within Alcoa and Jamalco.

9.2.2 DRAFT OCCUPATIONAL HEALTH AND SAFETY ACT 2003

The Occupational Health and Safety Act, 2003, which is in Draft form makes provision for a safe and healthy working environment for all working persons and to provide for matters incidental thereto or connected therewith.

The objects of the Act are as follows:

a. the prevention of injury and illness resulting from conditions at the workplace.

b. the protection of the safety and health of workers.

c. the promotion of safe and healthy workplaces.

As a good corporate citizen, Jamalco is committed to conducting its mining operation in a manner that complies with the requirements of this Act.

Some specific elements of these requirements are as follows:

- A joint committee of worker and management personnel shall be established at every workplace where twenty or more workers are regularly employed.
- An employer shall place in a conspicuous place in the workplace, a list containing the names and work locations of the members of the joint committee.
- Where fewer than twenty workers are regularly employed, the employer shall cause a safety and health representative to be selected.
- An employer shall make or cause to be made and maintain an inventory of all hazardous chemicals and hazardous physical agents that are present in the workplace.
- The employee shall make available to the workers the inventory of hazardous materials and pertinent Material Safety Data Sheets.
- Any worker who is likely to be exposed to hazardous chemical or physical agents must be provided with appropriate training and instruction.
- A worker has the right to refuse work if he has reasonable grounds for believing that his safety or health is endangered.

9.2.3 SOLID AND HAZARDOUS WASTE MANAGEMENT

The management of hazardous waste resulting from any aspect of the Mining Enterprise will be done in accordance with the Mining Regulations, 1991 of the Government of Jamaica as well as the applicable standards for Jamalco and the standards for Alcoa Operations worldwide. These include handling, segregation, storage and disposal considerations. If there are potentially toxic substances in the overburden and mine waste, they will be handled in such a way as to minimize the impact on rehabilitation and the surrounding areas.

The mining of bauxite and the processing of bauxite ore into alumina generates a wide variety of waste streams that must be properly handled and managed. Jamalco has very well defined procedures for the management of all waste streams generated at all its facilities.

Since the proposal for upgrade of the facility is one of "Brownsite" upgrade and no new or unfamiliar activities are proposed, the same time tested, high quality approach to waste collection, handling and management will be utilized. The following is an overview of how waste is managed at Jamalco presently and how it will continue to be managed after the upgrade.

9.2.4 SOLID WASTE MANAGEMENT

Solid waste generated at Jamalco includes, among other items:

- Used filters
- Empty drums
- Aerosol cans
- Garbage
- Boiler ash
- Demolition waste
- Medical waste
- Absorbents
- Office refuse
- Lime reject
- Waste Rags
- Sand

For each waste stream identified, there exists complete listing of tasks necessary for the collection, handling and management of that waste. The procedures identify sources of that particular waste stream, accumulation or storage locations and provides instruction on proper labeling, proper storage and individual responsibilities. The procedures are specific for all locations (plant, port, mines) and are comprehensive in its approach.

9.2.4.1 HAZARDOUS WASTE MANAGEMENT

Jamalco has strict requirements for the handling of hazardous waste materials. All waste streams considered hazardous waste are identified and listed by department and activity. As with all other waste streams at the facility, very specific tasks, procedures and instructions are provided. Jamalco utilizes satellite accumulation of its hazardous waste streams which are established based on international guidelines. These include:

- Waste collection containers must be located at or near the point of generation
- Waste containers must be in the control of the generator
- The collection station will be well marked and identified as “Satellite Collection Station”.
- The station shall be located in a secure and protected area. All waste must be labelled.
- Containers must be compatible with the waste being stored
- Container lids and bungs must be closed at all times
- Weekly inspections
- Container management

Examples of hazardous waste at JAMALCO include:

- PCB Waste
- Lead waste
- Spent solvents
- Sand blast residue
- Mercury Contaminated

9.2.4.2 LANDFILL MANAGEMENT PROGRAM

Jamalco owns and operates a landfill facility located in the northeast section of the refinery. This landfill is subject to the National Environment and Planning Agency’s Landfill Permit and License System and is operated within the local regulations and internal standards.

Jamalco has a complete list of items acceptable for disposal at the landfill site including special wastes such as regulated asbestos containing materials (RACM) which are deposited into an area within the landfill site that has been specially designed and sealed to accept these types of waste.

Specific internal rules and regulations govern the operation of the facility. Instructions on what type of waste is acceptable, mode of transportation, packaging, landfill maintenance, etc. are all specified in associated documentation. The landfill undergoes monthly inspections and specific forms designed for that purpose are used throughout the inspection process.

PUBLIC INVOLVEMENT

10 PUBLIC INVOLVEMENT

10.1 INTRODUCTION

Jamalco has an established record of consultation and cooperation with the communities, settlements and residents who are stakeholders in the area. This process of ongoing contact through meetings and activities provides Jamalco with an opportunity to understand and work with the communities expectations of the community.

During communication with the community, Jamalco provides information to the residents on ongoing activities and initiatives and coordinates mutually accepted solutions to address areas of concern. Jamalco intends on continuing this level of communication and dialogue with the communities throughout the entire upgrade process primarily through the five (5) Community Council groups with which they meet on a regular basis. These groups are:

- Port Community Council
- Refinery Community Council
- Railroad Community Council
- Pleasant Valley Community Council
- Havanna Heights Community council

These community groups comprise influential citizens, area leaders, community activists and individuals who have the best interest of the communities at heart.

10.2 COMMUNITY CONTRIBUTIONS

Over the years, Jamalco has played a major role as a good corporate citizen in the community. The company has been involved in the daily life and development of these communities in many ways, these include:

10.2.1 EDUCATION

- Established computer labs in six (6) High Schools, three (3) Primary Schools and Five (5) Basic Schools
- Cafeteria and bathroom expansion – Vere Technical High School
- Nutrition Programme – Daily supply of milk to 26 Basic Schools
- New bathrooms – Hayes
- Construction of a block of classrooms (Alcoa Block) including a Physics Lab
- Refurbished Vocational Department and upgraded electrical work in all classrooms – Lennon High School
- Back-to-school assistance for tertiary and high school students – annually
- Summer employment – students in tertiary institutions
- Support for the University of the West Indies – Labs, UWICED, distribute over 15,000 books annually for the past 14 years
- Skills training – sponsor students for HEART/NTA programmes and 4H clubs
- Developing skills training centre with HEART/NTA at Jamalco's Breadnut Valley facility

10.2.2 HEALTH

- Supply of medical supplies for clinics and hospitals – Islandwide
- Wellness programme – hypertension and diabetes checks – Mitchell Town, Hayes and Mocho
- Support – University Hospital Sickle Cell Unit, Kidney Unit, Cardiac Emergency Unit and Burn Unit

10.2.3 INFRASTRUCTURE UPGRADE

- Pave roads - Cornpiece
- Street lights improvements - Cornpiece
- Clean and construct new drains on a regular basis to alleviate flooding
- Constructed new Postal Agency – Mitchell Town
- Constructed new Post Office – Hayes
- Constructed Police Station – Hayes
- Expanded Health Center – Mitchell Town
- Constructed Community Center – Hayes
- Provided water supply system – Top Hill, Hayes

10.2.4 SPORTS

- Sponsor – Jamalco Community Netball Team
- Sponsor – Clarendon Netball League
- Sponsor – Various football teams

10.3 COMMUNITY CONSULTATION ON EFFICIENCY UPGRADE

Jamalco has consulted with members of the community on the proposed upgrade of the facility through their regular Community Council meetings and one specially arranged meeting. At the regular Community Council meetings, general information of the proposed upgrade was presented to the community representatives by Jamalco personnel. At the specially arranged meeting, the entire focus was on the upgrade project and details of the proposed upgrade were presented by the consultants conducting the EIA (Conrad Douglas & Associates Limited).

The meeting was attended by approximately 25 residents of surrounding communities. At this meeting, the details of the upgrade were presented by the consultant and any concerns or issues raised were noted and where possible, responses were provided.

Among the concerns raised were:

- Noise and vibration
- Atmospheric pollution
- Matters concerning transportation corridors
- Upgrade of community facilities
- Water Quality
- Employment

These concerns will be assessed for validation and engineering designs and management procedures, in keeping with Jamalco's ISO 14001 Certification will be used to address these concerns.

APPENDICES

11 APPENDICES

APPENDIX I: TERMS OF REFERENCE

ENVIRONMENTAL IMPACT ASSESSMENT

FOR

THE DISPOSAL OF BAYER PROCESS RESIDUE IN RDA #5

FOR JAMALCO

Conrad Douglas & Associates Limited (**CD&A**) has been contracted to conduct the Environmental Impact Assessment for the construction and operation of the proposed Residue Disposal Area #5 at JAMALCO, Clarendon.

Background

Jamalco is proposing to create a new Dry Bauxite Residue Disposal Area (DRDA #5) of approximate plan area 100 hectares, to the north of existing Residue Disposal Area (RDA) #4 and to the west of RDA #2. The project will continue to provide an environmentally friendly sound disposal method for bauxite residue.

The new DRDA will provide additional storage volume and surface area to accept bauxite residue from the Jamalco Refinery. Using Thickened Tailings Disposal with Dry Residue Stacking, this facility will provide capacity for storage of 8.0 million cubic metres of residue over six (6) years at current/projected production rates of 1.27/1.32 Mtpa.

The new RDA will be created by constructing a base layer incorporating seal and under-drainage over an area already partly excavated towards the probable DRDA #5 base level, during the 2002/2003 Jamalco RDA #3 & #4 Expansion Project.

The scope of the DRDA #5 Project will include, but is not limited to:

- Excavation of 80-100Ha base to design profile;
- Installation of geosynthetic liner on top of clay liner to base and embankments.
- Installation of under drainage system with probable 800-1000mm sand layer;
- Construction of perimeter drains and run-off pond;

- Installation of mud distribution piping;
- Installation of lake water return system;
- Installation of dust suppression sprinkler system;
- Provision for storage of rainfall run-off.

DRAFT TERMS OF REFERENCE

ENVIRONMENTAL IMPACT ASSESSMENT
FOR
THE DISPOSAL OF BAYER PROCESS RESIDUE IN RDA #5
FOR JAMALCO

Conrad Douglas & Associates Limited will conduct an Environmental Impact Assessment, which will detail the pre-construction, construction and operational aspects of the proposed Residue Disposal Area, in accordance with the requirements, standards and regulations of the National Environment and Planning Agency (NEPA) and Jamalco's Environmental, Health and Safety Policy and Procedures.

In the EIA, **CD&A** will:

1. Provide a comprehensive description of the existing site proposed for the development of the facility to store bauxite residue – detailing the elements of the project, highlighting areas to be reserved for construction and the areas which are to be preserved in their existing state and thoroughly reviewing the bauxite residue to be stored at the proposed site and the chemical processes (direct and incidental) involved. Detailed design calculations and drawings for the facility, including base and embankments will be presented. Seismic vulnerability assessment will be conducted and outlined.

2. Identify the major environmental issues of concern through the presentation of baseline data, which should include social and cultural considerations. An assessment of the public perception of the proposed development will also be done, utilizing information gathered from consultations with the local community. A Public Meeting will be conducted in support of the EIA Report.

3. Outline the Legislations and Regulations relevant to the project.

4. Predict the likely impacts of the proposed development on the described environment, including, direct, indirect and cumulative impacts – indicating their relative importance to the design of the development's facilities.

5. Identify mitigation action to be taken to minimize adverse impacts and quantify associated costs where applicable.

6. Design a monitoring plan, which should ensure that the mitigation plan is adhered to.

7. Describe the alternatives to the project that could be considered at the site.

CD&A will also provide full and detailed accounts in the following areas, prior to construction, during construction and the operational phases of the project:

1. **Description of the Project**:
    - Description of the area proposed to store bauxite residue in detail.
    - Description of detailed element of the project – highlighting areas to be reserved for construction as well as areas to be preserved in their existing state and, activities and features which will introduce risks or generate impact (negative and positive) on the environment.
    - Detailed design calculations and drawings for the facility, including base and embankments.
    - Seismic vulnerability assessment.
    - Use of maps, site plans and other graphic aids as appropriate.
    - Information on location, general layout and size of the project area.
    - Description of pre-construction, construction and post construction plans.
2. **Description of the Environment**

    Presentation of baseline data, which is to be used to describe the study area in respect of the following:

i. Physical environment inclusive of geology, hydrology (include impact of the modification of the topography on the hydrology of the area of the influence of the project).

   a. Determination of storm water run-off, drainage patterns and effect of the project on ground water.

   b. Slope stability issues.

   c. Water quality issues, leachate management.

   d. Climatic conditions and air quality in the area in the area of influence, including particulate emissions from stationary and mobile sources, NO_x, SO_x, wind speed and direction, precipitation, relative humidity and ambient temperatures.

   e. Noise levels at the undeveloped site and ambient noise in the area of influence.

   f. Obvious sources of pollution existing and the extent of contamination, including identification of any additional services that may arise from this project.

ii. Biological environment

   a. Description of any flora or fauna in the sphere of influence of the proposed project with special emphasis on rare, endemic or endangered species.

   b. Species dependence, niche specificity, community structure, population dynamics, carrying capacity, species richness and evenness (measure of diversity).

iii. Socio-economic and cultural constraints

   a. Present and projected population
   b. Present and projected land use

c. Planned development activities
d. Community structure
e. Employment
f. Distribution of income, goods and services
g. Recreation
h. Public health and safety
i. Cultural peculiarities
j. Aspirations and attitudes
k. Historical importance of the area
l. Public perception.

3. Policy, Legislations and Regulations:

- An outline of all pertinent policies, regulations and standards in keeping with the nature of the project will be provided. The examination of the legislation should include at a minimum, legislation such as the NRCA Act, legislation from the Solid Waste Management Authority (SWMA), Mining Act and as appropriate, international conventions, protocols, treaties, etc.

4. Determination of Potential Impacts:

- An identification of any major environmental issues of concern, and an indication of their relative importance to the design of the project with the intended activities.
- Determination of potential impacts related, but not limited to, the following:

a) Change in the drainage pattern and storm water management;

b) Flooding potential;

c) Landscape impacts of excavation and construction;

d) Loss of any natural features by construction activities;

e) Pollution of surface and ground water;

f) Solid waste disposal;

g) Air pollution;

h) Socio-economic and cultural impacts;

i) Risk assessment/Natural Hazard Vulnerability;

j) Noise;

k) Change in soil pH;

l) Waste disposal via recycling;

m) Accidental discharges into water bodies;

n) Impact of leachate;

o) Distinguish between positive and negative impacts.

p) Avoidable as well as irreversible impacts.

- Cumulative impacts.

5. Mitigation

- Preparation of guidelines for avoiding, as far as possible or eliminating, any adverse impacts due to proposed activity at the site while utilizing existing environmental attributes for optimum development. Where possible, quantification and the assignment of financial and economic values to impacts and mitigating methods will be done.

6. Monitoring

- Suggestion of a plan to monitor implementation of mitigation or compensatory measures and project impacts during construction and operation.
- Preparation of an Environmental Management Plan for the long-term operations of the site.

An outline of the monitoring program will be included in the EIA report and a detailed version will be submitted to NEPA after the granting of the permit and prior to the

commencement of the proposed development. The monitoring program will include the following, at a minimum:

- Introduction outlining the need for a monitoring program and the relevant specific provisions of the permit license granted;
- The activity being monitored and the parameters chosen to effectively carry out the exercise.
- The methodology to be employed and the frequency of monitoring.
- The sites being monitored, stating any outer boundary where no impact from the development is expected if stated by NEPA or other local agencies;
- A summary of data collected. Tables and graphs are to be used where appropriate;
- Discussion of results with respect to the development in progress, highlighting any parameter(s), which exceed(s) the standard(s).
- Frequency of reporting to NEPA.
- Recommendations;
- Appendices of data and photographs.

7. Project Alternatives

- Examination of alternatives to the project including the no-action alternative. (Project alternatives should incorporate the use history of the overall area in which the site is located and previous use of the site itself.)

CD&A will present all findings in the Environmental Impact Assessment, reflecting the headings in the body of the approved Terms of Reference, as well as other references. Eight hard copies and one electronic copy of the report will be submitted to NEPA. It will include an appendix with items such as maps, site plans, the study team, photographs and other relevant information.

APPENDIX II: SURVEY INSTRUMENT

Socio-Economic Survey for JAMALCO's Mining and Transport Operations in South Manchester

Community Name _____ Community Code | | | | | |

SECTION 1
PERSONAL CHARACTERISTICS

1) Gender
   1. Male
   2. Female

2) Age Range
   1. Under 20
   2. 20 – 39
   3. 40 – 49
   4. 50 – 59
   5. 60 – over
   6. Not Stated/No Response

3) How many years have you been living in the community?
   1. 0 – 5 Years
   2. 6 – 10 Years
   3. 11 – 20 Years
   4. more than 20 Years
   5. Not Stated/No Response

4) How is the traffic on the roads in your community?
   1. Too much traffic
   2. Not bad/ ok traffic
   3. More in the morning/ afternoon/ night
   4. Other _____

SECTION 2
OPINIONS ON THE COMMUNITY

5) What do you like most about the community? **(*ASK & WAIT FOR RESPONSE)***
   1. Friendly people
   2. Clean environment:
   3. Availability of farmland
   4. Quiet
   5. No crime & violence
   6. Other, (specify)_____
   7. Not Stated/No Response

6. What don't you like about the community? ***ASK & WAIT FOR RESPONSE***
    1. Poor roads
    2. Lack of Utilities
    3. Crime & violence
    4. Unemployment
    5. Dirty environment
    6. Other, (specify)_____
    7. Not Stated/No Response

SECTION 3
AWARENESS & OPINIONS ON EXISTING BAUXITE FACILITIES

7. Are you aware that there are bauxite lands in your community?
    1. Yes
    2. No

8. Are you aware that there is bauxite mining operations in your area?
    1. Yes
    2. No (Go to Q 11)
    3. Not Stated/No Response

9. What are your experiences with mining in your area?
    1. Negative
    2. Positive
    3. No impact

10. a) If negative, what? **(ASK AND WAIT)**
    1. Odour
    2. Traffic
    3. Dust, soot or gaseous emissions
    4. Noise
    5. Damage to your property
    6. Water quality
    7. Not stated/ No response
    8. Other _____

    b) How do you think this could be addressed? _____

    _____

    _____

11. Do you lease or use any bauxite lands?
    1. Yes
    2. No

12. If this land is needed for bauxite mining, what will you do?

    _____
    _____
    _____

13. How do you think the bauxite should be transported from the mines to the processing plant? **(ASK AND WAIT FOR RESPONSE)**
    1. Truck
    2. Conveyor
    3. Train
    4. Other _____

14. Would you say that bauxite mining operations have had negative impacts on the people in this community?
    1. Yes
    2. No (Go to Q 16)
    3. Not Stated/No Response

15. If **YES, ASK** - WHY WOULD YOU SAY THAT?
    1. The area has widespread corrosion
    2. The area smells like caustic soda more often than not
    3. You get sick more often
    4. Plants are harder to grow
    5. Too much noise
    6. Other (specify)
    7. Not Stated/No Response

16. Would you say that bauxite mining operations have had a positive impact on this community?
    1. Yes
    2. No

17. What positive impacts do you think bauxite mining operations have had on the community?

    1. Improved community relations
    2. Job opportunities
    3. Educational and social benefits
    4. Amenities – roads, lights, water supply
    5. Environmental conditions
    6. None of the above
    7. Other (specify)_____

8. Not Stated/No Response

SECTION 4
KNOWLEDGE AND VIEWS ON UPGRADE PLANS

18. Are you aware that JAMALCO proposes to expand their bauxite mining operations in or near your area?
    1. Yes
    2. No
    3. Not Stated/No Response

19. What effect do you think the proposed expansion of JAMALCO's bauxite mining operations in or near your area will have on the following: (**Answer in terms of positive, negative, no change, don't know. ASK AND WAIT)**

    i) Income/ Economic value of the community
    1. Positive
    2. Negative
    3. No Change
    4. Don't Know
    5. Not Stated/No Response

    ii) Job Opportunities
    1. Positive
    2. Negative
    3. No Change
    4. Don't Know
    5. Not Stated/No Response

    iii) Pollution
    1. Positive
    2. Negative
    3. No Change
    4. Don't Know
    5. Not Stated/No Response

20. Do you think the proposed upgrade will affect you personally?
    1. Yes
    2. No
    3. Don't Know/Not Sure
    4. Not Stated/No Response

SECTION 5
AVAILABILITY OF WATER

21. What is your main source of drinking water?

1. Indoor tap/pipe
2. Outdoor private tap/pipe
3. Public standpipe
4. Spring, pond, river
5. Rainwater (tank or drum)
6. Trucked water (NWC)
7. Other (specify)
8. Not Stated/No Response

22. "In this community, I think that we have access to safe water to drink" Do you agree?
    1. Yes
    2. No
    3. Don't Know/Not Sure
    4. Not Stated/No Response

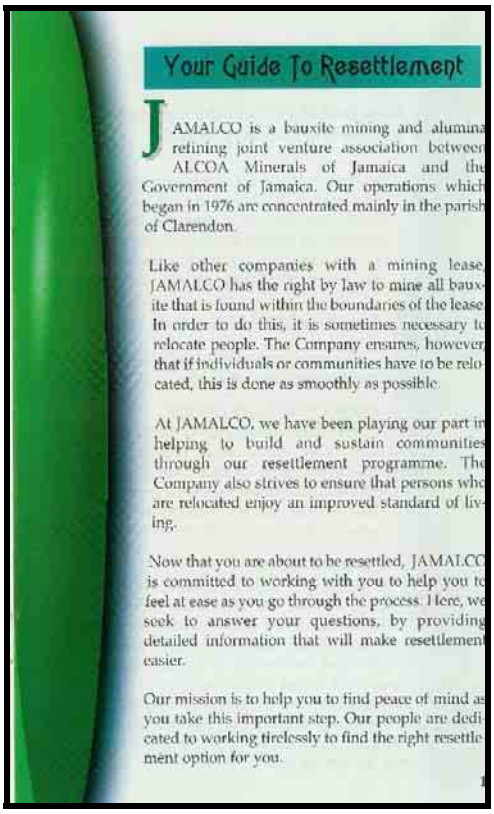
23. Why do you think so?
    1. bauxite mining affects the drinking water
    2. Sources (not bauxite mining or alumina processing related) affect the drinking water quality
    3. The water is tested frequently by the N.W.C.
    4. The water looks and/or smells clean
    5. Other, please specify
    6. Not Stated/No Response

24. Have you or any member of your household ever worked for a bauxite company or in the bauxite industry?
    1. Yes
    2. No
    3. Don't Know/Unsure
    4. Not Stated/No Response

25. Are you aware of any programs or activities initiated by bauxite companies in your community?
    1. Yes
    2. No
    3. Don't Know/Unsure
    4. Not Stated/No Response

Name of interviewer:
Signature of interviewer:
Date of interview:

APPENDIX III: 'JAMALCO AND YOU' Q & A BOOKLET



Your Guide To Resettlement

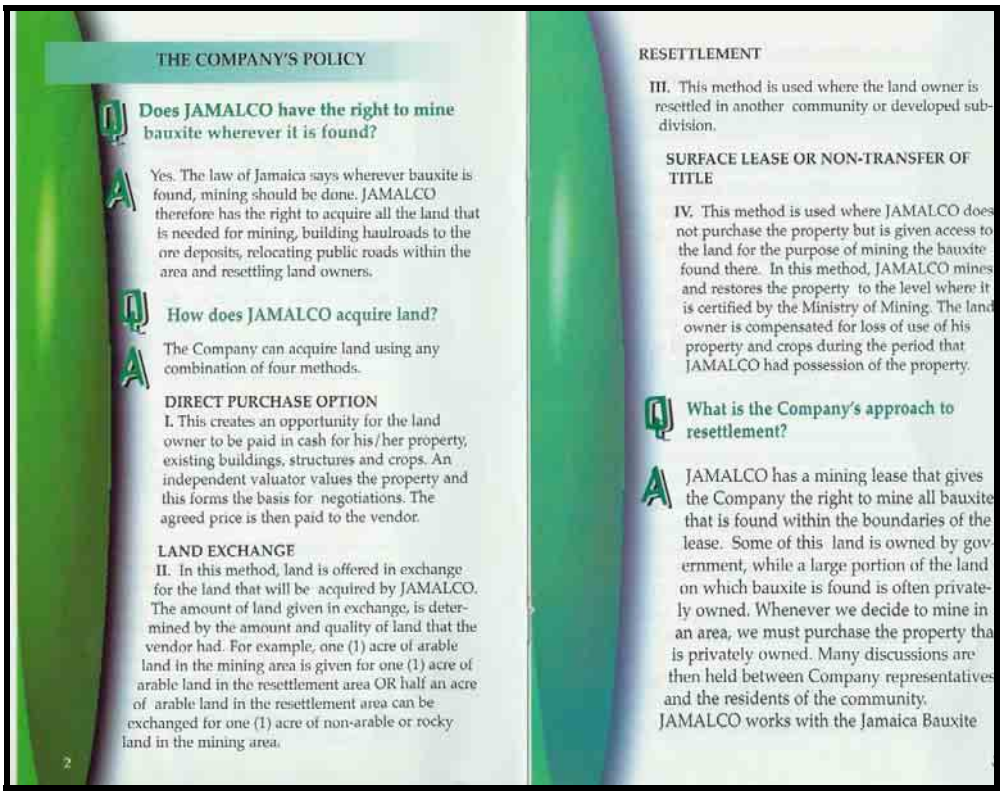
JAMALCO is a bauxite mining and alumina refining joint venture association between ALCOA Minerals of Jamaica and the Government of Jamaica. Our operations which began in 1976 are concentrated mainly in the parish of Clarendon.

Like other companies with a mining lease JAMALCO has the right by law to mine all bauxite that is found within the boundaries of the lease. In order to do this, it is sometimes necessary to relocate people. The Company ensures, however, that if individuals or communities have to be relocated, this is done as smoothly as possible.

At JAMALCO, we have been playing our part in helping to build and sustain communities through our resettlement programme. The Company also strives to ensure that persons who are relocated enjoy an improved standard of living.

Now that you are about to be resettled, JAMALCO is committed to working with you to help you to feel at ease as you go through the process. Here, we seek to answer your questions, by providing detailed information that will make resettlement easier.

Our mission is to help you to find peace of mind as you take this important step. Our people are dedicated to working tirelessly to find the right resettlement option for you.



THE COMPANY'S POLICY

Q Does JAMALCO have the right to mine bauxite wherever it is found?

A Yes. The law of Jamaica says wherever bauxite is found, mining should be done. JAMALCO therefore has the right to acquire all the land that is needed for mining, building haulroads to the ore deposits, relocating public roads within the area and resettling land owners.

Q How does JAMALCO acquire land?

A The Company can acquire land using any combination of four methods.

DIRECT PURCHASE OPTION

I. This creates an opportunity for the land owner to be paid in cash for his/her property, existing buildings, structures and crops. An independent valuator values the property and this forms the basis for negotiations. The agreed price is then paid to the vendor.

LAND EXCHANGE

II. In this method, land is offered in exchange for the land that will be acquired by JAMALCO. The amount of land given in exchange, is determined by the amount and quality of land that the vendor had. For example, one (1) acre of arable land in the mining area is given for one (1) acre of arable land in the resettlement area OR half an acre of arable land in the resettlement area can be exchanged for one (1) acre of non-arable or rocky land in the mining area.

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RESETTLEMENT

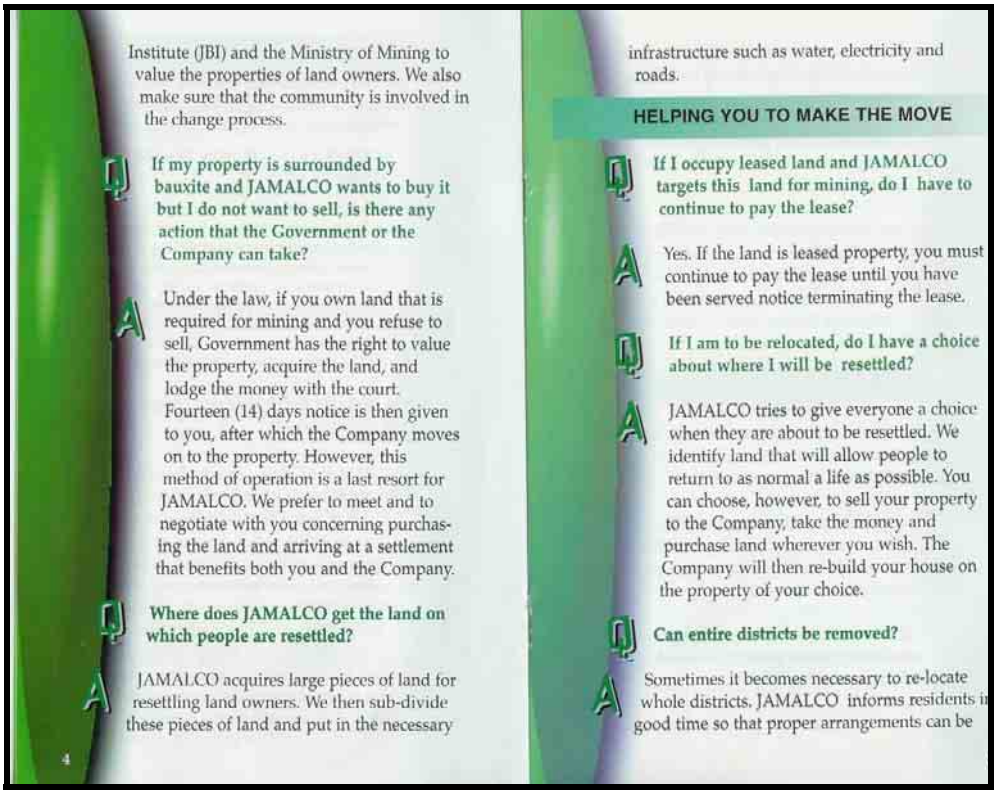
III. This method is used where the land owner is resettled in another community or developed sub-division.

SURFACE LEASE OR NON-TRANSFER OF TITLE

IV. This method is used where JAMALCO does not purchase the property but is given access to the land for the purpose of mining the bauxite found there. In this method, JAMALCO mines and restores the property to the level where it is certified by the Ministry of Mining. The land owner is compensated for loss of use of his property and crops during the period that JAMALCO had possession of the property.

Q What is the Company's approach to resettlement?

A JAMALCO has a mining lease that gives the Company the right to mine all bauxite that is found within the boundaries of the lease. Some of this land is owned by government, while a large portion of the land on which bauxite is found is often privately owned. Whenever we decide to mine in an area, we must purchase the property tha is privately owned. Many discussions are then held between Company representatives and the residents of the community. JAMALCO works with the Jamaica Bauxite



Institute (JBI) and the Ministry of Mining to value the properties of land owners. We also make sure that the community is involved in the change process.

Q If my property is surrounded by bauxite and JAMALCO wants to buy it but I do not want to sell, is there any action that the Government or the Company can take?

A Under the law, if you own land that is required for mining and you refuse to sell, Government has the right to value the property, acquire the land, and lodge the money with the court. Fourteen (14) days notice is then given to you, after which the Company moves on to the property. However, this method of operation is a last resort for JAMALCO. We prefer to meet and to negotiate with you concerning purchasing the land and arriving at a settlement that benefits both you and the Company.

Q Where does JAMALCO get the land on which people are resettled?

A JAMALCO acquires large pieces of land for resettling land owners. We then sub-divide these pieces of land and put in the necessary

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infrastructure such as water, electricity and roads.

HELPING YOU TO MAKE THE MOVE

Q If I occupy leased land and JAMALCO targets this land for mining, do I have to continue to pay the lease?

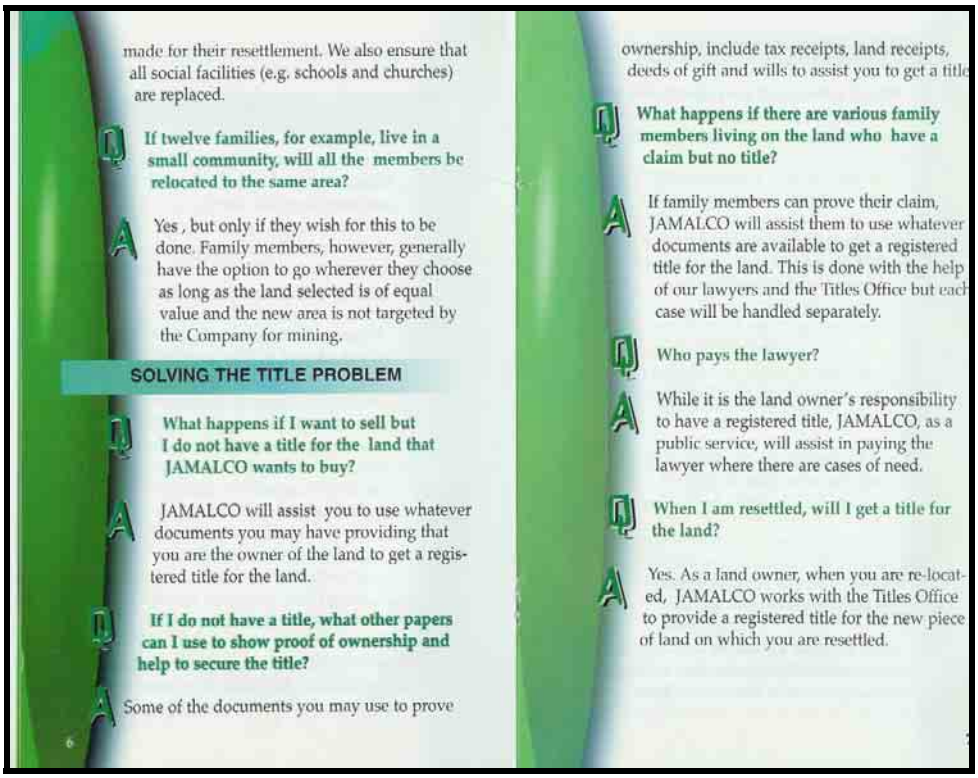
A Yes. If the land is leased property, you must continue to pay the lease until you have been served notice terminating the lease.

Q If I am to be relocated, do I have a choice about where I will be resettled?

A JAMALCO tries to give everyone a choice when they are about to be resettled. We identify land that will allow people to return to as normal a life as possible. You can choose, however, to sell your property to the Company, take the money and purchase land wherever you wish. The Company will then re-build your house on the property of your choice.

Q Can entire districts be removed?

A Sometimes it becomes necessary to re-locate whole districts. JAMALCO informs residents i good time so that proper arrangements can be



made for their resettlement. We also ensure that all social facilities (e.g. schools and churches) are replaced.

Q **If twelve families, for example, live in a small community, will all the members be relocated to the same area?**

A Yes , but only if they wish for this to be done. Family members, however, generally have the option to go wherever they choose as long as the land selected is of equal value and the new area is not targeted by the Company for mining.

SOLVING THE TITLE PROBLEM

Q **What happens if I want to sell but I do not have a title for the land that JAMALCO wants to buy?**

A JAMALCO will assist you to use whatever documents you may have providing that you are the owner of the land to get a registered title for the land.

Q **If I do not have a title, what other papers can I use to show proof of ownership and help to secure the title?**

A Some of the documents you may use to prove ownership, include tax receipts, land receipts, deeds of gift and wills to assist you to get a title

Q **What happens if there are various family members living on the land who have a claim but no title?**

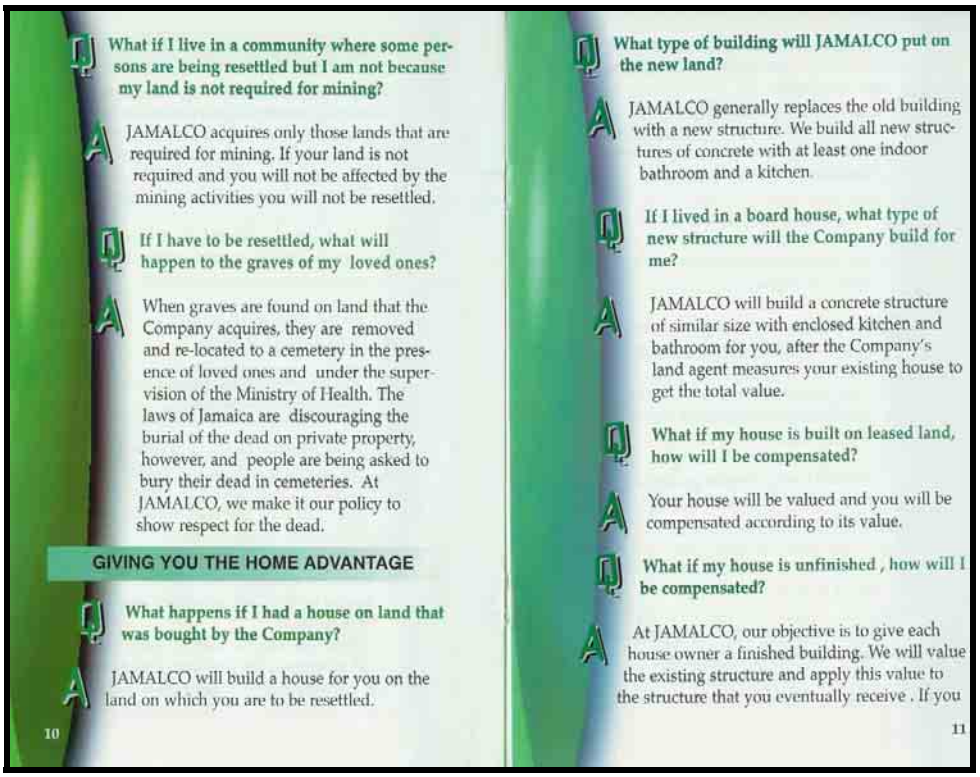
A If family members can prove their claim, JAMALCO will assist them to use whatever documents are available to get a registered title for the land. This is done with the help of our lawyers and the Titles Office but each case will be handled separately.

Q **Who pays the lawyer?**

A While it is the land owner's responsibility to have a registered title, JAMALCO, as a public service, will assist in paying the lawyer where there are cases of need.

Q **When I am resettled, will I get a title for the land?**

A Yes. As a land owner, when you are re-located, JAMALCO works with the Titles Office to provide a registered title for the new piece of land on which you are resettled.



Q What if I live in a community where some persons are being resettled but I am not because my land is not required for mining?

A JAMALCO acquires only those lands that are required for mining. If your land is not required and you will not be affected by the mining activities you will not be resettled.

Q If I have to be resettled, what will happen to the graves of my loved ones?

A When graves are found on land that the Company acquires, they are removed and re-located to a cemetery in the presence of loved ones and under the supervision of the Ministry of Health. The laws of Jamaica are discouraging the burial of the dead on private property, however, and people are being asked to bury their dead in cemeteries. At JAMALCO, we make it our policy to show respect for the dead.

GIVING YOU THE HOME ADVANTAGE

Q What happens if I had a house on land that was bought by the Company?

A JAMALCO will build a house for you on the land on which you are to be resettled.

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Q What type of building will JAMALCO put on the new land?

A JAMALCO generally replaces the old building with a new structure. We build all new structures of concrete with at least one indoor bathroom and a kitchen.

Q If I lived in a board house, what type of new structure will the Company build for me?

A JAMALCO will build a concrete structure of similar size with enclosed kitchen and bathroom for you, after the Company's land agent measures your existing house to get the total value.

Q What if my house is built on leased land, how will I be compensated?

A Your house will be valued and you will be compensated according to its value.

Q What if my house is unfinished , how will I be compensated?

A At JAMALCO, our objective is to give each house owner a finished building. We will value the existing structure and apply this value to the structure that you eventually receive . If you

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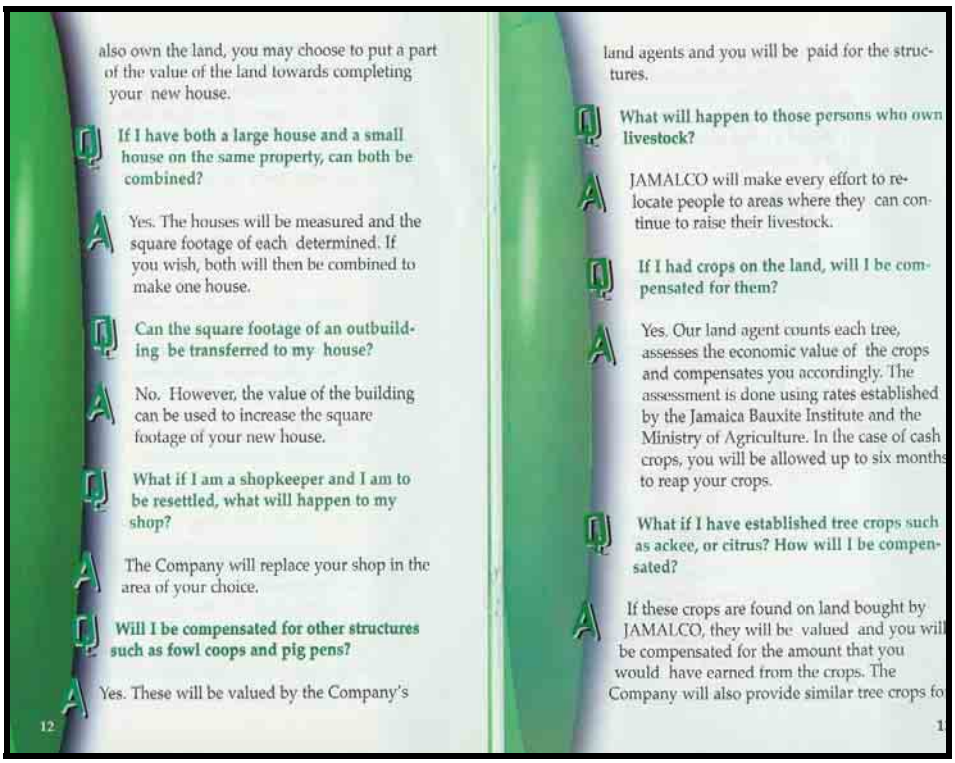

also own the land, you may choose to put a part of the value of the land towards completing your new house.

Q If I have both a large house and a small house on the same property, can both be combined?

A Yes. The houses will be measured and the square footage of each determined. If you wish, both will then be combined to make one house.

Q Can the square footage of an outbuilding be transferred to my house?

A No. However, the value of the building can be used to increase the square footage of your new house.

Q What if I am a shopkeeper and I am to be resettled, what will happen to my shop?

A The Company will replace your shop in the area of your choice.

Q Will I be compensated for other structures such as fowl coops and pig pens?

A Yes. These will be valued by the Company's

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land agents and you will be paid for the structures.

Q What will happen to those persons who own livestock?

A JAMALCO will make every effort to re-locate people to areas where they can continue to raise their livestock.

Q If I had crops on the land, will I be compensated for them?

A Yes. Our land agent counts each tree, assesses the economic value of the crops and compensates you accordingly. The assessment is done using rates established by the Jamaica Bauxite Institute and the Ministry of Agriculture. In the case of cash crops, you will be allowed up to six months to reap your crops.

Q What if I have established tree crops such as ackee, or citrus? How will I be compensated?

A If these crops are found on land bought by JAMALCO, they will be valued and you will be compensated for the amount that you would have earned from the crops. The Company will also provide similar tree crops fo

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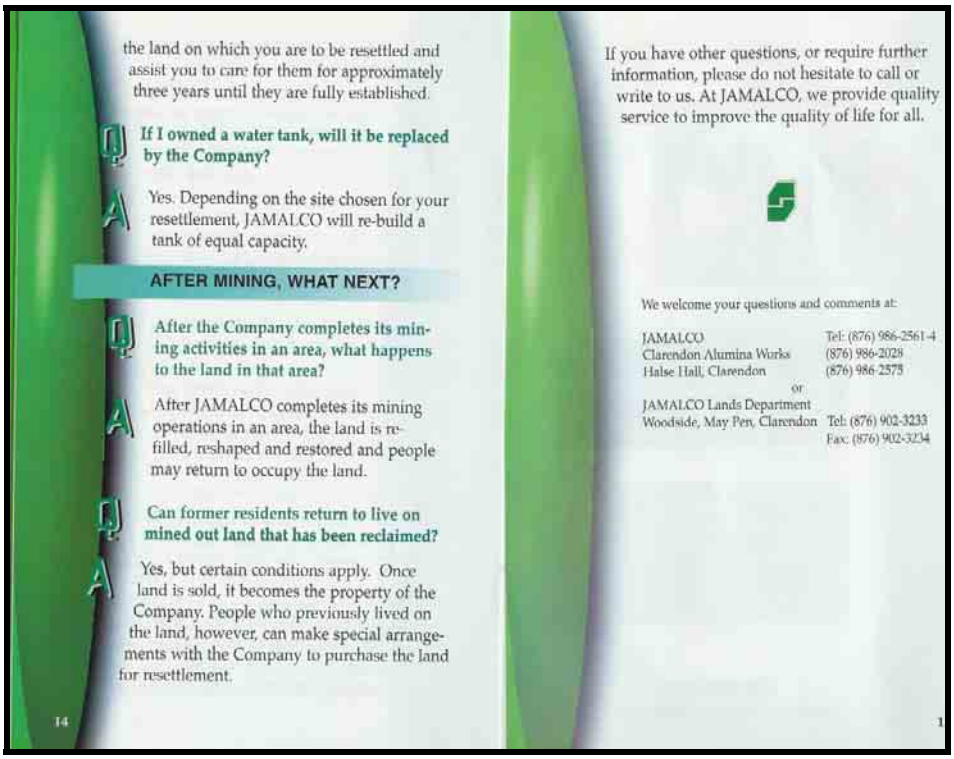

the land on which you are to be resettled and assist you to care for them for approximately three years until they are fully established.

Q **If I owned a water tank, will it be replaced by the Company?**

A Yes. Depending on the site chosen for your resettlement, JAMALCO will re-build a tank of equal capacity.

AFTER MINING, WHAT NEXT?

Q **After the Company completes its mining activities in an area, what happens to the land in that area?**

A After JAMALCO completes its mining operations in an area, the land is re-filled, reshaped and restored and people may return to occupy the land.

Q **Can former residents return to live on mined out land that has been reclaimed?**

A Yes, but certain conditions apply. Once land is sold, it becomes the property of the Company. People who previously lived on the land, however, can make special arrangements with the Company to purchase the land for resettlement.

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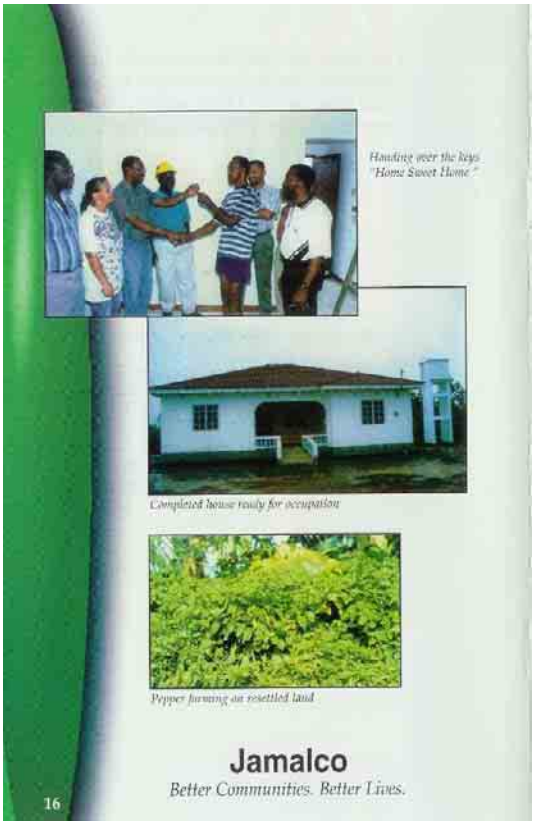
If you have other questions, or require further information, please do not hesitate to call or write to us. At JAMALCO, we provide quality service to improve the quality of life for all.

We welcome your questions and comments at:

JAMALCO	Tel: (876) 986-2561-4
Clarendon Alumina Works	(876) 986-2028
Halse Hall, Clarendon	(876) 986-2575
or	
JAMALCO Lands Department	
Woodside, May Pen, Clarendon	Tel: (876) 902-3233
	Fax: (876) 902-3234


Handing over the keys
"Home Sweet Home"
Completed house ready for occupation
Pepper farming on resettled land
Jamalco
Better Communities. Better Lives.
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APPENDIX IV: REFORESTATION PLAN IN JAMAICA – MEMORANDUM OF UNDERSTANDING BETWEEN MINISTRY OF AGRICULTURE- FORESTRY DEPARTMENT AND ALCOA.

CLARENDON, JAMAICA -- Alcoa and Jamaica's Forestry Department have signed an agreement to work together to rehabilitate reclaimed mined-out lands through reforestation on the island. The five-year accord includes developing a public education program, planting of suitable trees, and a research program aimed at enhancing the development and reforestation of the lands

JAMALCO and the Forestry Department in the Ministry of Agriculture (GOJ)have signed a memorandum of Understanding (MOU), to establish a framework for collaboration for the successful rehabilitation of reclaimed mined-out lands through reforestation of these areas.

This five year accord, signed recently by Jerome Maxwell, JAMALCO'S Managing Director and Marilyn Headley, Conservator of Forests, at the Halse Hall Great House in Clarendon, will see the Forestry Department and JAMALCO partnering to effect this restoration of adequate plant cover.

Guided by the 'no-net-loss' policy, the two organizations will work to compensate for the loss of forest cover due to mining operations. This move will see the establishment of new forests on selected reclaimed bauxite mined out areas as well as the protection and preservation of existing forests.

Under the MOU, the Forestry Department will utilize its skills for the establishment and management of forests, along with a forest research program aimed at enhancing the development and reforestation of the lands.

According to Miss Headley, this is in keeping with the Forestry Department's mandate outlined in the Forest Act of 1996 and which includes privately owned properties such as the JAMALCO lands.

At the signing, Mr. Maxwell, described the MOU as “timely and reflective of JAMALCO’s environment protection policies and Alcoa’s worldwide ‘One Million Trees’ project.”

Specific areas of cooperation agreed on in the MOU include the development of a public education program for farmers and students to improve understanding of the contribution of forests to local and national well-being and economic development. Provisions have also been made for other areas of collaboration to be explored.

The agreement also specifically mandates the planting of suitable ornamental and lumber tree species such as cedar, ficus, acacia, wild tamarind, blue mahoe, mahogany, bitter wood, bitter damson, and spanish elm along with fruit trees such as mango, orange, avocado, breadfruit and ackee.

Appendix IV – Forest Reserves of Jamaica

Forest Reserves of Jamaica

· conservation of naturally existing forests

· as a source of forest products

· for the conservation of soil and water resources

· to provide parks and other recreational facilities for public use

· as a habitat for the protection and conservation of endemic flora and fauna

· the forest reserve areas shown in the Gazette are estimates, based on descriptive, not surveyed, boundaries

A programme of surveying forest reserve boundaries is underway and survey data are being digitised which will produce more accurate maps. In the years since the Forestry Department was established in 1937, the government has set aside a significant portion of its land for forest

reserves. They now amount to over 111,000 hectares or over 10 percent of the country's total area. These protected areas provide us with a be cared for so that their benefits

can be enjoyed by future generations. The 1996 Forest Act provides for the creation and protection of forest reserves for the following purposes:

Most of the country's forest reserves are located in areas of rugged terrain such as the John Crow Mountains, Blue Mountains and Cockpit Country as well as the dry, hilly uplands in the south, west and north-west portions of the country. Despite their remoteness, serious encroachment has taken place. The 1998 analysis of forest cover and land use in Jamaica, carried out by the Forestry Department, shows that more than 20 percent of land within forest reserves has been impacted by human activity such as conversion to agricultural and/or residental use, mostly without Forestry Department permission.

Under the Forest Act, the Minister may declare to be forest reserves any Crown land, or private land if the owner requests such a declaration.

Further, the Minister may order or declare any land not in a forest reserve to be a forest management area, including private land if he is satisfied that the use of the land should be controlled for the protection of the national interest. Crown lands may be declared a protected area if required for a number of purposes specified in the Forest Act, including flood and landslide .Further, the Minister may order or declare any land not in a forest reserve to be a forest management area, including private land if he is satisfied that the use of the land should be controlled for the protection of the national interest.

Crown lands may be declared a protected area if required for a number of purposes specified in the Forest Act, including flood and landslide protection, soil preservation, erosion, maintenance of water supply and protection of amenities, flora and fauna. On protected areas cultivation, grazing, burning and clearing of vegetation is prohibited or strictly regulated.

The forest reserve areas listed in the following table are garnered from The Jamaican Gazette. The records show that the area of forest reserves and Crown lands managed by the Forestry Department is 109,514 hectares, of which 98,962 hectares are forest reserves and 10,552 hectares are Crown lands. These figures from the Gazette show a variation from those compiled by the Forestry Department in its recent assessment of forest cover and land use. The reasons for the difference are:

· the forest reserve areas compiled by the Forestry Department during its assessment were digitised from 1:250 000 maps and not from actual surveyed forest reserve boundaries.

Parish Remarks

Forest Reserves of Jamaica by Parish

Forest Reserve/

Crown Land Name

Area (ha) Reference in the

Manchester Denham Farm 20.00 27-09-1956 486 Part of Devon Land Settlement

Gourie 141.65 Crown

Hudson's Bottom 226.63 Crown

John Anderson 121.40 Crown

New Forest 160.78 01-12-1950 432 Part of New Forest Land Settlement

Oxford 133.55 Crown

Ramble 48.18 01-12-1950 435

St. Jago A 163.90 09-10-1969 654 Plan A, Vol 1030 Fol 433

St. Jago B 66.00 09-10-1969 654 Plan B, Vol 1030 Fol 433

Virginia 13.03 01-12-1950 434 Part of Virginia Land Settlement

Total Manchester 472 623

Clarendon Bull Head 220.06 01-12-1950 417

Kellets-Camperdown 1497.79 01-12-1950 417

Kellits Stream A 8.30 01-12-1950 425 Block A (Miller's Spring)

Kellits Stream B 1.62 01-12-1950 425 Block B (Mosquito River)

Peace River 116.70 25-06-1959 423

Peak Bay A 302.72 01-12-1950 433 Block A

Peak Bay B 152.57 01-12-1950 433 Block B

Peak Bay C 60.70 01-12-1950 433 Block C

Peckham 70.89 01-12-1950 426 Prev. 06-09-1945 (part of Peckham Land Sett.)

Pennants A 169.19 01-12-1950 437 Block A (part of Pennants Land Sett.)

Pennants B 59.40 01-12-1950 438 Block B (part of Pennants Land Sett.)

Pennants (Douces) A 26.42 01-12-1950 438 Block A (part of Pennants Land Sett.)

Pennants (Douces) B 3.07 01-12-1950 438 Block B (part of Pennants Land Sett.)

Pennants (Douces) C 2.55 01-12-1950 438 Block C (part of Pennants Land Sett.)

Portland Ridge 5612.30 Crown Vol 403 Fol 40

Teak Pen A 532.99 01-12-1950 439 Block A (part of Teak Pen Land Sett.)

Teak Pen B 149.74 01-12-1950 440 Block B (part of Teak Pen Land Sett.)

Total Clarendon 3375 5612

St. Catherine Dawson Mountain 1 55.04 Crown Lot 101, Mount Dawson Land Settlement

Dawson Mountain 2 75.86 Crown Lot 104, Mount Dawson Land Settlement

Harkers Hall 6.82 01-12-1950 425 Prev. 06-09-1945 (Harkers Hall Land Sett.)

Healthshire Hills 4856.40 01-12-1950 422

Treadways 26.39 01-12-1950 422 Part of Treadways Land Settlement

Troja 18.86 21-07-1955 362 Lot 41, Troja Land Settlement

Twickenham Park 2.06 Crown

Little Goat Island 6.00 30-06-1960 278 2.4 km south of the mainland

Great Goat Island 188.00 30-06-1960 278 2.0 km south of the mainland

Total St. Catherine 5102 133

APPENDIX V: TEAM MEMBERS

Project Team

- **Dr. Conrad Douglas**
- **Mr. Paul Thompson**
- **Dr. Art Reid**
- **Prof. Edward Robinson**
- **Ms. Winsome Young**
- **Orville Grey**
- **Mr. Burklyn Rhoden**
- **Mr. Noel Watson**
- **Geomatrix Ltd.**
- **Ms. Dahlia Bean**
- **Deonne Caines**
- **Mr. Vance Johnson**

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