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24 October 2002

National Director
Republic of Mozambique
Ministry for the Coordination of Environmental Action
National Directorate for Environmental Impact Evaluation
Av. Acordos de Lusaka, 2115
MAPUTO

Attention : Drª F.N. Munguambe

Dear Madame

DRAFT ENVIRONMENTAL IMPACT ASSESSMENT REPORT FOR A HAZARDOUS WASTE HANDLING FACILITY, MAVOCO - BELULUANE, MATOLA.

Please find attached the draft environmental impact assessment report for the new hazardous waste handling and treatment facility at Mavoco. Also included is Document B comprising the specialist reports, for your perusal and comment.

We trust that the report will meet with your favourable recommendation. Please do not hesitate to contact us with any inquiries and queries.

We remain available to assist you with any environmental aspects that you should require.

Yours sincerely

TR VAN VIEGEN
for AFRICON Lda

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I ABBREVIATIONS

AP	Administrative Post
BID	Background Information Document
BPEO	Best Practicable Environmental Option
DNAIA	Danish Government Cooperation
EIA	Environmental Impact Assessment
EIE	Environmental Impact Evaluation
EIR	Environmental Impact Report
EMP	Environmental Management Plan
GCL	Geosinthetic clay layer
IFZ	Industrial Free Zone
I&APs	Interested and Affected Parties
MICOA	Ministry for the Coordination of Environmental Affairs.
MCDT	Mozal Community Development Trust
PPP	Public Participation Process
RAP	Relocation Action Plan
TSDF	Treatment, Storage and Disposal Facilities
UNEPA	United States Environmental Protection Agency

II GLOSSARY OF DEFINITIONS

Basel Convention: The Convention controls the trans-boundary movement of hazardous wastes and their disposal.

Background Information Document: A document drafted by the EIA team to feed into the PPP. The BID will provide project background and an introduction to the PPP.

Best Practicable Environmental Option. BPEO is the outcome of a systematic consultative and decision-making procedure that emphasizes the protection of the environment across land, air and water. It establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole at an acceptable cost in the long term and as well as the short term.

Carcinogens: A substance or agent producing or inciting cancer. These substances can be grouped as: Group A - Clinically and epidemiologically proven in humans, Group B - Proven without doubt in laboratory animals, Group C - limited evidence in animals, Group D - Inadequate and doubtful data.

Co-Disposal (General Waste with Hazardous Waste): The mixing and joint disposal of Hazardous (H) and General (G) waste in the same landfill. The co-disposal of General Waste with Hazardous Waste as a means of facilitating disposal on an H site is acceptable, whereas the co-disposal of any significant quantity of Hazardous Waste with General Waste on a General Waste disposal site is unacceptable.

Co-Disposal (liquid with dry waste): The mixing of high moisture content or liquid waste with dry waste. This affects the water balance and is an acceptable practice on a Hazardous Waste site, but is only acceptable on a General Waste site equipped with leachate management measures.

Contaminate: The addition of foreign matter to a natural system. This does not necessarily result in pollution, unless the attenuation capacity of the natural system is exceeded.

Corrosive: Solids or liquids that can, in their original state, severely damage living tissue. Corrosivity can be measured by determining the degree to which a standard coupon of steel dissolves.

Darcy's Law: The flow of liquids through soils can be illustrated by experimental techniques similar to those used by **Darcy** (1856). Darcy's law thus describes the relationship between the flow volume through soil in time, which is proportional to the cross-sectional area of the soil and to the difference in piezometric levels and inversely proportional to the length of the flow path. For the velocity of percolation of water in saturated soil; states that Velocity = coefficient of permeability x hydraulic gradient.

Destruction: To neutralise or get rid of a waste by incineration or other physical or chemical means.

Dispersion: The movement of a substance from a landfill into the surrounding environment.

Domestic waste: Waste emanating, typically, from homes and offices. Although classified as a General Waste, this waste contains organic substances and small volumes of potentially hazardous substances.

Ecotoxicity: Ecotoxicity is the potential to harm animals, plants, ecosystems or environmental processes.

Environmental Impact Assessment: A process of assessing the potential impact of a proposed activity on the environment and the surrounding community. The process involves the assessment of both biophysical and social impacts to propose mitigation and make final recommendations.

Environmental Impact Report: A document produced as the output of an EIA process, to document all issues identified, opportunities and constraints, findings, impacts and mitigation recommendations.

Effluent: A waste stream flowing from a larger stream, lake, sewerage tank, industrial process.

Environmental Management Plan: A document that contains recommendations for the control or management of the potential significant impacts of operations on the environment and to contain or mitigate actual impacts.

Encapsulation: The coating or enclosure of waste within an inert durable material. Micro-Encapsulation: the coating of individual particles of a waste. Macro-Encapsulation: the isolation of the wastes in sealed, reinforced concrete cells or capsules. The capsules are then located in a demarcated area of an H landfill site.

Engineered Cell: A cell that is lined so as to contain Hazardous Waste and prevent leachate from the waste escaping from the cell.

Environment: Associated cultural, social, soil, biotic, atmospheric, surface and ground water aspects associated with the landfill that are, or could potentially be, impacted upon by the landfill.

Exposure: The amount of a hazardous substance available to man or living matter.

Feasible: Acceptable, capable of being used or implemented successfully, without unacceptably damaging the environment.

Flammable Liquids: Liquids which give off a flammable vapour at or below 61°C using the closed cup test. The **closed cup testing system** is used to determine the flash point of various elements or mixtures.

Flammable Solids: Substances, other than those classed as explosives, which are readily combustible or may cause or contribute to fires.

General Waste Landfill: A landfill that can accept General Waste. Hazardous Waste may not be disposed of at a General Waste Landfill.

General Waste: Waste that does not pose an immediate threat to man or to the environment, i.e., household waste, builders' rubble, garden waste, dry industrial and commercial waste. It may, however, with decomposition, infiltration and percolation, produce leachate with an unacceptable pollution potential. (See Waste.)

Generator: The Generator is an industry or other party whose activities result in the production of waste. The responsibility for a Hazardous Waste remains from cradle-to-grave with the Generator of that waste and the Generator is held liable for any damage that the waste may cause to humans or to the environment.

Hazard Rating: The rating into which a Hazardous Waste falls when it has been Hazard Rated, see below.

Hazard Rating: A system for classifying and ranking Hazardous waste according to the degree of hazard they present. This is based on Mammalian Acute and Chronic Toxicity, Ecotoxicity, and Environmental Fate. Based on this, Hazardous waste is classified as: Extreme Hazard, Hazard Rating 1; High Hazard, Hazard Rating 2; Moderate Hazard, Hazard Rating 3; and Low Hazard, Hazard Rating 4.

Hazardous Waste: Waste, other than radioactive waste, which is legally defined as Hazardous in the state in which it is generated, transported or disposed of. The definition is based on the chemical reactivity or toxic, explosive, corrosive or other characteristics which cause, or are likely to cause, danger to health or to the environment, whether alone or when in contact with other waste. *After UNEP definition.* (See Waste.)

Hazardous Waste (alternative definition): Waste that may, by circumstances of use, quantity, concentration or inherent physical, chemical or infectious characteristics, cause ill-health or increase mortality in humans, *fauna* and *flora*, or adversely affect the environment when improperly treated, stored, transported or disposed of. (See Waste.)

Hazardous Waste Landfill (H): A containment landfill, designed specifically for the disposal or co-disposal of Hazardous Waste.

Interested and/or Affected Parties: Members of the public or local communities with an interest in the project and the outcome of the study that register with the facilitators as I&APs.

Immobilisation: Immobilisation (or chemical stabilisation) is a process in which the waste is converted to a more chemically stable or more insoluble or more immobile form.

Industrial Groups: Industries or activities, which are likely to produce a Hazardous Waste.

Landfill (v): To dispose of waste on land, whether by use of waste to fill in excavations or by creation of a landform above grade, where the term "fill" is used in the engineering sense.

Landfill (n): The waste body created by landfilling. This may be above or below grade, or both.

Leachate: An aqueous solution with a high pollution potential, arising when water is permitted to percolate through decomposing waste. It contains final and intermediate products of decomposition, various solutes and waste residues.

Leachate Management: The collection and drainage of leachate to a point where it can be extracted for treatment. This requires a system of under-drains and liners and, in certain instances, is synonymous with containment.

Liner: A layer of low permeability placed beneath a landfill and designed to direct leachate to a collection drain or sump, or to contain leachate. It may comprise natural

materials, synthetic materials, or a combination thereof. (See also FML and Geomembrane.)

"Machamba" – Agricultural plot.

MICOA – Ministry for the Coordination of Environmental Affairs. This Ministry was established in December 1994 and it is the central/national government body responsible for coordinating environmental issues in Mozambique.

Minimum Requirement: A standard by means of which environmentally acceptable waste disposal practices can be distinguished from environmentally unacceptable waste disposal practices.

Neutralisation: To render harmless or less hazardous by the addition of acid or alkali to bring the pH in the region of 7.

Permeability (Primary): The rate at which fluid will pass through a porous material under a unit flow gradient. The constant of proportionality K in Darcy's Law is measured in m3 /year, m2/year or m/year.

Permeability (Secondary): The rate at which fluid will pass through macro features of a soil, such as paleo-root canals, termite tunnels and rodent burrows, under unit flow gradient. **Paleo-root canals** are flowpaths created in the geology due to the removal of ancient roots or organic materials

Precipitation: Precipitation is the addition of lime, sodium sulphide or other reagents that result in the formation of insoluble compounds that come out of solution.

Public Participation Process: A process of facilitating the participation of the general public in the EIA process. The process includes advertising and media notification, public meetings and local community involvement, keeping of an I&APS register and establishing of an issues report for inclusion in the final documentation.

Recycle: The use, re-use, or reclamation of a material so that it re-enters the industrial process rather than becoming a waste.

Responsible Person: A person(s) who takes professional responsibility for ensuring that all or some of the facets of the handling and disposal of Hazardous Waste are properly directed, guided and executed, in a professionally justifiable manner.

Risk: The scientific judgement of probability of harm.

Significant: Factors or considerations are termed significant when they are important, because they are of consequence. For example, they will have a detectable influence on a process, the environment, or the end result.

Significant leachate generation: Seasonal or continuous leachate generation resulting mainly from climate and/or waste moisture content. In the case of existing landfills, significant leachate generation may also result from poor site selection and/or design. It is essential that significant leachate generation be managed by means of leachate collection and treatment if water pollution is to be avoided.

Solidification: Solidification or cementation is a process in which the waste is converted to an insoluble rock-like material by mixing with suitable materials.

Toxic: Poisonous.

Transporter: A person, organisation, industry or enterprise engaged in or offering to engage in the transportation of waste.

Treatment: Treatment is used to remove, separate, concentrate or recover a hazardous or toxic component of a waste or to destroy or, at least, to reduce its toxicity in order to minimise its impact on the environment.

Waste: An undesirable or superfluous by-product, emission, or residue of any process or activity which has been discarded, accumulated or stored for the purpose of discarding or processing. It may be gaseous, liquid or solid or any combination thereof and may originate from a residential, commercial or industrial area. This definition excludes industrial waste water, sewage, radioactive substances, mining, metallurgical and power generation waste. (See General Waste and Hazardous Waste.)

Waste Body: This refers to the body of waste (and cover) that is contained in the landfill. Because it is subject to decomposition, it has the potential to generate leachate and must therefore be adequately separated from the water regime.

Waste Disposal (v): The act of disposing of waste.

Waste Disposal Site: Any place at which more than 100 kg of a Hazardous Waste is stored for more than 90 days or a place at which a dedicated incinerator is located is termed a Waste Disposal Site.

Waste Stream: A continuous flow of waste from an industry, activity, process or group.

III EXECUTIVE SUMMARY

SECTION 1: PROJECT BACKGROUND AND INTRODUCTION

Current industrial developments in and around Maputo have necessitated the establishment of a hazardous waste landfill facility for the safe disposal of waste from Maputo City, Mozal, other industries and the rest of Mozambique.

After considering five sites the Mavoco site was chosen as the most environmentally acceptable site. Criteria such as: land use planning, land occupation density, use of natural resources, need for displacement, cultural aspects, public health, distance to the site from industrial activities, Maputo and other potential client areas, accessibility, protection of species and habitats and limited public consultation were used to identify the site.

After selection of the preferred site Africon was appointed by MICOA to conduct the EIA on the chosen site and access route and to review the engineering design. The aim of this Public Participation Process and EIA is to find the best alternative access route alignment to the chosen site with minimal environmental and social impact and to record all potential impacts and propose mitigation for the development of the site itself. Mitigation measures proposed for the construction and operation of the facility and the access road will be described in detail in the EMP.

SECTION 2: PROJECT DESCRIPTION

The Mavoco site is located in the Beluluane area, north-west from the Motraco power station and west-north-west of the Mozal Smelter. The site lies east of the road between Moamba and Boane, east of the Xingube River and approximately 33km from Maputo city.

The components of the waste facility will comprise one landfill cell with operational dividing bund walls, a leachate buffer and management system, temporary waste storage system, access road, weighbridge, operational hard surfaced areas, administration buildings/workshops, laboratory, waste stabilization unit, fire protection system, borehole water supply, sewage systems, fencing, power and lighting supply, telephone system and the development of a new access road to the facility.

An initial area of 10 ha out of a total of 50 ha is required for the establishment of the facility infrastructure, and sufficient landfill capacity for the first 10 years of disposal. The initial establishment would involve a 5-year cell, plus infrastructure lasting 10-year with provision for future expansion to a 20-year capacity.

In both urban and industrial disposal the largest concern is the liquids known as leachate which is composed of heavy concentrations of dissolved compounds that can contaminate local water supplies. Instances of groundwater contamination by leachate typically results in the loss of potable water for many decades.

The proposed Mavoco waste treatment and storage facility will be developed primarily to cater for the fluorinated waste stream from Mozal, and for the anticipated hazardous waste stream from within Mozambique. A higher order engineered hazardous waste landfill facility (H:H classed facility according to regionally and internationally acceptable standards), will be developed. It will be a containment structure built essentially from

excavated clay materials thus creating a bathtub effect and lined with synthetic products and constructed clay layers to ensure an impervious liner below the waste.

Control of the waste stream would be required at all times from where it is collected at the source and transported to the landfill facility. Proper transportation equipment and vehicles would be required to convey the waste to the landfill and which will be travelling on a durable and surfaced roadway. The intention is to limit the possibility of any spillage of the waste on-route to the waste disposal facility.

The proposed approach for the design of the new Mavoco Hazardous Waste Facility is to establish a Temporary Storage and Handling Facility for the small quantities of problematic waste that cannot be landfilled directly due to its chemical nature. Such waste would be stored until such time as there is sufficient quantity to warrant exporting for safe destruction, or to establish onsite treatment facilities.

The fluorinated waste products from Mozal will require cement or lime stabilization to immobilize the fluoride in the waste. In this facility the fluorinated waste will be blended with cement or lime prior to disposal in the landfill cells. The intention is also to allow for ash blending of liquid waste such as oily sludges and tannery waste at the blending facility which will be part of the disposal facility.

The leachate and contaminated water will be managed in storage ponds and / or be spray irrigated over the landfill with the intention to minimize the leachate through evaporation. The liner system will consist of a leachate collection system (plastic pipe network), compacted clay layers, geomembranes and geotextiles will act as a pollution prevention barrier system.

Once the available landfill volume is exhausted and built up to the designed height and capacity, the landfill is covered and rehabilitated to an environmentally acceptable state.

SECTION 3: LEGAL AND INSTITUTIONAL REVIEW AND INTERNATIONAL PRACTICE

The development of a hazardous waste landfill at Mavoco is governed by legislation, protocols, guidelines, white papers, etc based not only on Mozambique's Enabling legislation and Article 8.3 of the Environmental Impact Assessment Regulations approved by Decree no. 76/98 but also supported by regional legislation as promulgated in Swaziland, South Africa, Zimbabwe, Zambia and Botswana.

The Articles 37 and 72 of the Constitution determine the general policies and principles guiding the protection and preservation of the environment. The legal instrument through which the Government recognizes the interdependency of "development" and "environment" is found in Resolution 5/95, dated August 3rd – "Política Nacional do Ambiente" (National Environment Policies) which leads to the implementation of social and macro-economic policies.

The Environment Act, Law 20/97, dated October 1st – "Lei do Ambiente", establishes the legal grounds for the correct use and management of the environment and its components. The act defines Hazardous Waste - "Lixos ou Resíduos Perigosos"- as substances or objects which are disposed of, or are intended to be disposed of, or are required by law to be disposed of, and which are inherently dangerous because they are inflammable, explosive, corrosive, toxic, infectious or radioactive, or due to any other inherent characteristic that might represent a risk to the life or health of people and/or other life-forms, or might adversely affect the environment.

Decree 76/98, dated December 29th – "Regulamento sobre o Processo de Avaliação do Impacto Ambiental" (Environmental Impact Assessment Regulations) and general directives regarding Environmental Impact Assessments, July 2000 specify the procedures and steps to be observed whenever an Environmental Impact Assessment is to be carried out and specify the licensing of consultants responsible for the administration of the process. The EIA process is the basic step for an environmental license to continue with a proposed development and is the basis for this EIA.

Until national standards are adopted, the evaluation criteria to be complied with should be those standards approved by international organisations.

Chapter IV (articles 146 to 165) of the Law 8/98, dated July 20th – "Lei do Trabalho" - Labour Law refers to the conditions regarding the Workers Hygiene, Safety and Health. These articles define the rights of the workers and their respective employers.

Through resolutions no 18/96 and 19/96 respectively, dated 26th November 1996, Mozambique became signatories to the Basel Convention regarding the Control of Transboundary Movements of Hazardous Waste and their Disposal and the Bamako Convention regarding the Interdiction of Importation of Hazardous Wastes and the Control of Transboundary Movements of Hazardous Waste in Africa.

The development of the new Mavoco Hazardous Waste Facility is based on the internationally accepted waste management series guidelines as published by the South African Department of Water Affairs and Forestry, Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste and the Minimum Requirements for Waste Disposal by Landfill, Second Editions, 1998.

SECTION 4 ENVIRONMENTAL BASELINE DESCRIPTIONS OF THE SITE

Biophysical

The morphology of the region is characterised by smoothly undulating terrain formed by inland dunes with altitudes ranging from 50 m to 100 m above mean sea level (asl). The study area itself forms a gentle slope of about 2%, which ends at the Rio Movene (Xingube River) in the west.

The site is located on the eastern edge of the Movene Formation of the Lebombo Group. There is a clear geological contact running roughly north-south through the site, between the outcropping volcanic formation (Basalt/Rhyolite) on the west, and sedimentary formation on the east.

The site comprises predominantly moderately deep sands in the southeast and hard rock in the northwest. The site is underlain by predominantly clay sandy soils of relatively low permeability, which renders the site suitable for the development of a waste disposal facility. The clay sand is however not suitable for use in a compacted clay liner unless there is some bentonite addition.

Two distinct aquifers have been identified on site. These include, a shallow or upper aquifer, generally associated with the young/recent sand deposits and colluvial materials, and a deeper aquifer associated with the fractured rock, or fractured rock aquifer. At the proposed site, there is evidence of a fractured rock aquifer associated with the Rhyolites, Basalts and younger intrusive bodies (dolerite).

The shallow alluvial aquifer is utilized by the local population throughout the area. The water is tapped from the sands either by shallow boreholes, or from caisson or open hand dug type wells. There are no boreholes within a six-kilometre radius of the area.

The closest spring is 2,8km to the southeast of the site, and is believed to be associated with the shallow alluvial aquifer. The water quality is moderate to poor, with the majority of the water encountered being brak to the taste and mostly unsuitable for human consumption.

Although not quantified at present there are indications of some associated seismic risk within the region. The climate of Maputo province is tropical humid to sub-humid, with rainfall distributed along the year. The mean annual rainfall is 800 mm. The mean annual temperature is 23 °C with the average monthly humidity values which ranges from 60 - 75 %. The average annual, total evaporation is 1250 mm. Eastern winds are dominant in the area with average wind speeds which vary seasonally, from 2 m/s in winter to 4 m/s in summer. Cyclone winds, typical of the rainy, warm season are seldom registered.

Biological

The study area is characterized by secondary vegetation forming an open-woodland, with medium to low height trees, and herbaceous cover dominated by grasses. Ecologically the vegetation can be classified as climatic, where the plant communities are primarily dependent on atmospheric humidity, precipitation and air temperature. As a result of human pressure, the vegetation shows a biogenetic change in features, testified by a number of native and exotic fruit trees occurring scattered in the area. Small scale farming of mostly maize and cassava takes place in the area.

Some indigenous fruit trees of rare occurrence in the region were observed, namely *Strychnos spinosa* and *Manilkara discolor*. A common feature to most of the areas is the occurrence of xerophytes species. In relatively deep soils pod mahogany trees were also identified. The Caster Oil plant occurs occasionally. The former is found in the marginal areas of "machambas", where it is semi-cultivated for medicinal purposes (i.e. it is planted once and later reproduces spontaneously).

In relatively shallow soils 12-15 m high *Aloe marlothii* is found in grassland dominated by an association of *Themeda* and *Hyparrenia*. These species are the most important in the area close to the Southwest border of the study area. In this area, the change in soil type is evident. In the sub-plateau area in the South of Mozambique the vegetation with these characteristics is generally found in rocky outcrops with shallow soils that are rich in Iron and Magnesium.

Floristically the vegetation is composed of a variety of native and exotic trees, scrub and shrub species, used by local communities for a number of purposes such as timber and charcoal production, handcrafts, household firewood, food, livestock grazing and medicine. In areas where the original grass has been replaced with small-scale farming, maize and cassava constitute the predominant crops along with beans and pumpkin. 55 Main plant species can be found in and around the area, in relatively reduced numbers.

Most of the fauna of the area is not restricted to the area and can be found in similar habitats in the region and its diversity is closely related to the soil types, the vegetation and on the use of those resources. The fauna of the area is limited to small animals including insects, reptiles, birds and a reduced number of small mammals. Rodents are the most common mammals; the most abundant include the lesser cane rate and the "house mouse". They are both socio-economically important species due to the damages to crops by the former and to food stored in granaries by the latter.

37 Bird species have been identified in the Beluluane area. Domestic animals occurring in the area are mostly chickens and ducks and to a lesser extent (in isolated cases cattle) wild rabbits and pigs, can also be found. A few dogs and cats may also be kept as

pets. Although not restricted to the area bird species, rodents, the "house mouse", snakes and the guinea fowl are sporadically seen in the area. Some bats were observed near an area of dead trees. In the past the area comprised a relative variety of Klipspringer, the red duiker and the common duiker.

The Socio-Economic Context of the Study Area
The study area is located in the Southern Mozambican Province of Maputo, situated within the Administrative Post (AP) of Matola Rio in the District of Boane with a total geographic area of 820 km².

The District Administration provides coordination and facilitation for the District Directorates of Agriculture and Rural Development, Health, Public Works, Education, and a district police commandant. The Administrative Post of Matola Rio comprises seven population centers (povoações). The AP Matola Rio is characterized by an overwhelmingly rural population whose primary activity and source of income is agricultural.

Despite its current profile as largely rural, the AP Matola has undergone a series of dramatic changes over the course of the past four years, which include the construction of the Mozal plant and its supporting infrastructure. Mozal has also contributed to the development of the Matola Rio AP with regard to health services, education, markets and other basic infrastructure improvements as well as the development of the Beluluane Industrial Park (BIP). The vast majority of the Matola Rio AP is still largely undeveloped agricultural small-holder land that comprises populations which earn their livelihoods predominantly from agricultural production complemented by small scale non-agricultural activities such the commercialisation of natural resource products such as firewood and charcoal.

According to the 1997 census data, the population of Matola Rio AP is 12,120 of which 45.3% is male and the 54.7% is female.

Principal Non- Agricultural Activities in Matola Rio are Mozal, the only heavy industry; light industrial such as a ceramics factory, block making for housing and commercial construction, salt production and sand mining for construction activities; services industry with restaurants and nightclubs (or quintas), small shops, as well as guesthouses and small hotels for accommodation and three official markets. Although viewed as inadequate the social service network addresses the health and education needs of the population.

Mavoco area:
Mavoco was established in the late 1950s. The dominant ethnic group in the community is the MaRonga ethnic group and their principal language is Ronga.

Agriculture within the Mavoco area is primarily smallholder based, subsistence agriculture. Their principal crops of the subsistence smallholder farmers are: Cassava, Maize, Peanuts Sweet Potato and butter beans, with limited tomato and sesame production. There is no large-scale livestock farming within the Mavoco area. The settlement patterns in the Mavoco area can be described as dispersed (farming based) settlement patterns. The two principal non-agricultural income generating activities for the local population are the production of charcoal from the local forest resources and the the gathering and selling of firewood.

The Mavoco community receives water from traditional sources in the area such as springs and traditional open topped wells. The primary source for household energy in Mavoco for cooking is firewood collected from the local area. Social Services in Mavoco

include education and health facilities. The elders of the community indicated that they were unaware of any graves that were located within the study areas. Despite the fact that the community of Mavoco is just outside of Mozal's operational zone, the MCDT has been working in Mavoco to support the relocated farmers who have machambas in the area, allocated as part of the resettlement program.

"Macro" issues that need to be taken into consideration when assessing the community of Mavoco and any potential impacts of the proposed facility on the community are historical relocations, floods, location of industrial developments, civil war and resettlement and compensation of local community members. Planned industrial development, is crucial to ensure that the needs of the local community are taken into consideration with continues development around Mavoco. These plans must guarantee that future industrial developments in the area will not compromise the community's ability to sustain their livelihood. Viable, acceptable and transparent alternatives should be found for the local population should further development require the relocation of the local population.

SECTION 5: EIA AND PP PROCESSES

The legislation requires that the **Environmental Impact Assessment** (EIA) procedure for the proposed development have to be followed. This entails a permitting process meeting various environmental reporting requirements. The findings of the EIA Report inherently form the foundation of the EMP - which will encompass the construction and operational aspect of the EIA process. The EMP will contain the necessary mechanisms, guidelines and requirements (as identified by the EIA Report) to minimise the long-term detrimental effect of the development activity on the environment through the design, construction and operational phases of the development life cycle.

As part of public involvement, four important **public meetings** took place in the course of the study. The 1st Meeting concentrated on EIA and engineering aspects of the project. This information provided the basis for people to concentrate on possible potential impacts. A further meeting dealt with concerns of the community and compensation for losses incurred. The second meeting dealt with the concerns over other waste generated in the area, the operations, required investigations and the continuous involvement by the public in the operations of the facility. The last meeting focussed on the need for the Mavoco Hazardous Waste Landfill Site to be constructed and operated based on sound national and international environmental and social guidelines and standards. Industrial and other potential users of the project's services need to be educated and encouraged to understand the benefits of disposing industrial hazardous waste in the facility. Old and current practices need to be abandoned as soon as the facility is made available.

The **Socio Economic Impact Assessment** (SIA) as conducted during the EIA has three primary objectives within the broader context of the EIA namely to provide detailed background on the social and economic factors, to identify potential positive and negative impacts of the proposed facility and to present mitigating measures to be undertaken in order to minimize the negative impacts of the hazardous waste facility.

All relevant secondary literature for the conduct of the SIA was reviewed and evaluated including documentation provided by MICOA, MOZAL and local authorities and the relevant specialist studies completed in the context of the EIS for Phase 1 of the Mozal development. An overall list of interested and affected parties was established within the context of the public participation process. In addition to the public meetings that formed part of the Public Participation Process, individual meetings were held with various local

and national government officials, a list of individual contacts during the scope of this work are provided in Appendix G.

After reviewing the secondary literature, the area of direct influence of the project (or the Project Impact Zone) was defined as approximately a two-kilometre radius around the site, while the Road Influence Zone was determined to be a two-kilometre path along either side of the access road. The fieldwork for this project included various visits to the project site and to the Mavoco area and included interviews with community members, and traditional and governmental authorities.

The primary components of the fieldwork were semi structured interviews, an inventory of infrastructures along the access road alternatives 1 and 2 and specific meetings held with the community. The Public Participation Process provided fundamental feedback and points for consideration that were raised by the general population.

SECTION 6: RISK DETERMINATION

Evaluation of the geotechnical investigation revealed that **a detailed seismic risk assessment of the site must be conducted and if required, that the landfill cells and structures must be designed for such a hazard.**

The conclusions and recommendations of the **geotechnical** assessment is summarised as follows:

- The regional and site geology must be reviewed and a map must be produced indicating the site geology, dykes, faults, etc of the site.
- Neither the stiffness (at natural moisture conditions and during an increase in moisture content) nor the collapse potential of the in situ soil profile was determined.
- It is recommended that the expansive potential of the soil profiles be reassessed.
- The presence of ferricrete nodules encountered at shallow depth in some test pits is indicative of the presence of perched water table conditions during a wet season.
- It is recommended that a detailed seismic risk assessment of the site be conducted.

The conclusions and recommendations of the **geohydrological** technical assessment can be summarised as follows:

- It is concluded that the Mavoco Waste Handling Facility has all the required geohydrological properties for a good site, containing any contamination with minimal impact on the groundwater environment.
- It is recommended that investigations regarding drilling, modelling and water analyses be completed to fully understand and manage the Mavoco facility.
- There is a need for an ongoing monitoring programme.

The main aim of the **air quality** impact study was to determine the potential for health, odour and dust impacts due to the Mavoco Hazardous Waste Landfill and to project suitable buffer and management zones for the site, if deemed necessary.

A final conclusion on transportation could not be drawn due to a lack of information.

Odour impacts and odour management zone projection revealed a:

- Possible buffers of between 100 and 300m from any residential development;
- The need for an ongoing monitoring programme.

The **Fugitive Dust Impacts** assessment pointed towards:

- Suggestions to select a treated road option.
- Dust from roads could be reduced by speed and traffic reduction, source improvement (e.g. tarring, gravelling or slag), and surface treatment (chemical stabilization).
- Dust suppression by watering and wind sheltering.

The **Gaseous Impacts** assessment revealed no need to develop any community buffer zones based on health impacts.

SECTION 7: ENGINEERING REVIEW OF DESIGN

The review of the design of the disposal facility was done by comparing it against the objectives of the South African *Minimum Requirements* as baseline standard.

As suggested in the findings of the geotechnical and geohydrological information regarding the seismicivity in the region, clarification is sought as this could have an impact on the design.

Overall the site is found to be suitable for a hazardous waste facility as it offers a natural barrier against potential environmental impacts, is accessible, can be controlled and the drainage of uncontaminated and contaminated water is manageable.

While stating a number of pre-treatment options the design does not address the required potential additions or alterations required to the proposed facility in the event that an alternative specific treatment process is required. The proposed process of waste stabilization with cement or lime is supported as it is expected to reduce the mobility of the hazardous constituents within the waste and that it will make the waste easier to manage. Apart from the temporary storage of waste in the transfer area, the guidelines as set out in the Minimum Requirements have been followed and all aspects of a thorough design are represented in the Mavoco hazardous waste disposal facility.

The proposed operating plan is found to be comprehensive dealing with legal and management as well as health and safety requirements. This document is also used to provide training of staff and ensures replication of operational practices, when there are changes in staff. However, no reference is made to disaster recovery procedures in terms of environmental protection and should be addressed.

The design of the facility has taken the local population and their physical environment, more specifically the water resources, hydrogeology of the region, the geology of the region, mitigation of the potential environmental impacts, attaining and maintaining minimum waste management standards in Mozambique into account.

Provided the operations are managed by a suitably qualified operating company, it could be found to be a practical and feasible solution to the disposal of the hazardous waste products. Issues regarding the foundations, potential treatment options and temporary storage however require further review.

SECTION 8: DESCRIPTION OF ALTERNATIVES CONSIDERED

Facility:
Mozambique does not have a hazardous waste site and the no-go option would therefore imply continuing with the status quo, which would lead to a long-term impact on the environment and the people of Mozambique.

International awareness of the consequences of a lack of hazardous waste management plans, highlighted by the Basel Convention that Mozambique ratified, led to the identification of 5 areas to be evaluated for the potential development of a hazardous waste landfill site. Each of the sites were assessed and ranked according to socio-economic, biophysical and public consultation criteria using a rating matrix. The Mavoco (Beluluane site 2B) site was recommended as the preferred site for the hazardous waste facility.

The development of a facility would lead to:

- Less illegal dumping and co-disposal of hazardous/industrial and domestic waste
- Decrease in illegal storage of hazardous waste.
- Controlled treatment of hazardous waste.
- Controlled transportation of hazardous waste.
- Decrease in environmental damage.
- Emergency procedures in place to deal with spillages and leakages.

Access Road:
Critical to the Mavoco Hazardous Waste Facility and its operations is the access to the site. A number of alternatives have been proposed for the access road to the Hazardous Waste Facility. Two alternatives for the **pavement design** have been proposed namely:

- The Access Road will have an unsurfaced width of 6 m with 150 mm wide shoulders on either side with unlined trapezoidal side drains. Major impacts associated with this gravel road are dust and noise.
- The recommended alternative of an Access Road that will have a surfaced width of 6 m with 150 mm wide unsurfaced shoulders on either side, constructed from the emulsion stabilised base material. This alternative compared to a gravel road will have a positive impact socially.

Three preliminary **route alignment** alternatives were identified.

ALTERNATIVE 1: Following the Motraco electricity lines from Motraco to the facility in a parallel line outside the servitude.	**ALTERNATIVE 2: The same as alternative 1 with two deviations to avoid "machambas" and a marshy area.**	**ALTERNATIVE 3: Following the existing Moamba - Boane road (EN2) with an existing road from the EN2 to the facility.**
Relocation of 50-60 formal Mavoco resettlement machambas a 2nd time. Compensation for 2nd relocation and crops in the field costly.	Relocation of 25-35 informal machambas. Compensation for crops in the field.	This route goes through the heavily populated city of Boane.
Resettlement of 4-7 households with compensation for loss of housing and farmland	Resettlement of 4-10 households with compensation for loss of housing and farmland	No households will be impacted on the existing road from the EN2 to the facility.
A marshy area next to the transmission line will be crossed, making construction difficult and costly.	The route will deviate around the marshy area, resulting in less costly construction of the road.	A bridge will have to be constructed across the Movene River on the existing 2,5 km from the EN2 to the

		facility.
The road construction near the Motraco line could impact on cable stays of the pylons – disrupting electricity supply.	The road construction near the Motraco line could impact on cable stays of the pylons – disrupting electricity supply.	This road crosses rivers that are used for potable water and irrigation purposes. There is an increased environmental risk of spillages.
The route is approximately 6 km long from the Motraco yard to the facility.	The route is approximately 7 km long from the Motraco yard to the facility.	Increased travel time and distance (40km from Mozal) will increase risk of exposure and potential spillage and disasters.
The Motraco oil sump will have to be relocated.	The Motraco oil sump will have to be relocated.	The entire route will require increased erosion protection and stormwater management to diminish pollution effects next to the road.
The route is straight and poses minimum risk in terms of road safety for transportation vehicles.	This route has a technical risk associated with the 2-4 turns in the road to deviate around the marshy area and machambas. Proper design would be needed to ensure road safety for transportation vehicles.	Sections of the EN2 road will have to be rehabilitated to increase road safety for large vehicles transporting hazardous waste (shoulders, barriers, cat eyes etc.)

Summarizing the opportunities and constraints of the above, the alternatives can be grouped into two. Alternative 1 and 2 can be grouped into one, named the Motraco Route access alternative with alternative 2 as the mitigation for alternative 1.

ASPECT	MOTRACO ALTERNATIVE	Time period	MOAMBA - BOANE (EN2) ALTERNATIVE	Time period
Social cost – relocation of machambas	25-35 informal machambas = medium impact	Short term	Informal machambas / loss of arable land = low impact	Short term
Compensation for houses & machambas	4-10 houses and informal machambas = high impact	Medium term	No houses = no impact	Short term
Loss of crops and cleared machambas.	Medium impact	Medium term	Loss of arable land – no crops at present = low impact	Short term
Loss of income	High impact	Short term	No impact	Short term
Loss of resources	Wood and charcoal = High impact	Medium term	Wood and charcoal = High impact	Medium term
Transportation cost regarding length of road	± 6km from the Motraco yard = low impact	Long term	± 40 km from Mozal = high impact	Long term
Environmental risk	Minimum risk of spillage = low impact	Long term	Longer route – risk of spillage = high impact	Long term
Pollution of ground / potable water	Minimum risk = Low impact	Long term	Increased risk associated with route length = high impact	Long term
Pollution of crops – reducing quality	Short route = low impact	Long term	Long route = high impact	Long term

Conclusion and recommendation:
The social cost associated with the Motraco route alternative is outweighed against the environmental risk and escalating transportation cost of the Moamba-Boane road. **It is**

with two deviations is the preferred alternative for the proposed access road. Alternative 3 should be investigated in much more detail if this option is to be considered in the future.

SECTION 9 & 10: IMPACT EVALUATION AND MITIGATION FOR THE FACILITY AS WELL AS THE ACCESS ROAD

These sections categorise and identify the single environmental aspects, which have informed the list of ***pertinent*** issues, which have been identified by specialist research, I&AP representation and the assessment evaluation. These listed issues have been determined through the environmental impact assessment, the scoping process, the public participation process and the site visit.

Impacts identified were divided into impacts that could occur during the planning and design phase, construction phase, operation phase and the rehabilitation phase.

The significant impacts identified through the above process are listed below.

- Dust generation
- Noise
- Emissions of pollutants
- Impacts on the natural flooding regime of the Movene River catchment area
- Pollution and siltation of water bodies
- Pollution of potable water sources – springs/wells
- Leachate permeating through liner – pollution
- Change in visual/ aesthetics of the area
- Erosion
- Destruction of fauna and flora
- Loss of grazing and arable land
- Loss of resources
- Loss of cultivated Machambas
- Reduction in crop quality and quantity
- Conflicts in landuse
- Encroachment
- Health and safety
- Risk of major spills and environmental disasters

These impacts have been evaluated and mitigation measures proposed and included in the detail construction, operational and rehabilitation EMP for the facility and the access road.

SECTION 12: CONCLUSION AND RECOMMENDATION

10.1 Conclusion and recommendation for the Hazardous Waste Facility:

The status quo "no-go" situation that currently occurs in Mozambique could result in major environmental damage over the long run. Cleaning this waste and rehabilitating the environment, transferring hazardous waste and treatment of the waste is becoming increasingly costly. Spillages and impacts associated with hazardous waste could only become known (without regular monitoring), years after it took place and by that time it could be to late to prevent a major disaster. It is therefore recommended that the no-go alternative not be investigated further.

With proper planning and design of the facility to accommodate mitigation measures into environmental management of the facility, the environmental and social risk associated with hazardous waste could be limited. The existing situation for disposal of hazardous waste in Mozambique and the associated potential risk to human health and the environment could only improve with the development of a hazardous waste facility.

Facility treatment processes:

The proposed process of waste stabilization with cement or lime is supported as it is expected to reduce the mobility of the hazardous constituents within the waste and that it will make the waste easier to manage. Apart from the temporary storage of waste in the transfer area, the guidelines as set out in the Minimum Requirements have been followed and all aspects of a thorough design are represented in the Mavoco hazardous waste disposal facility.

The **Gaseous Impacts** assessment for the facility revealed no need to develop any community buffer zones based on health impacts.

Recommendation:

- Control of the waste stream would be required at all times from where it is collected at the source and transported to the landfill facility. Proper transportation equipment and vehicles would be required to convey the waste to the landfill and which will be travelling on a durable and surfaced roadway. The intention is to limit the possibility of any spillage of the waste on-route to the waste disposal facility.
- A detailed seismic risk assessment of the site must be conducted and if required, the landfill cells and structures must be designed for such a hazard.
- The regional and site geology must be reviewed and a map must be produced indicating the site geology, dykes, faults, etc of the site.
- It is recommended that the expansive potential of the soil profiles be reassessed.
- It is recommended that investigations regarding drilling, modelling and water analyses be completed to fully understand and manage the Mavoco facility.
- An ongoing monitoring programme must be implemented before construction activities commence (status quo determination), to determine potential pollution of ground and surface water.
- A buffer zone (without residential development) of between 100 m and 300 m must be established around the facility to mitigate **Odour** impacts and odour management.
- An ongoing monitoring programme must be implemented before construction activities commence (status quo determination), to determine potential air pollution.
- A suitably qualified operating company should manage the operations of the facility.
- Treatment procedures for the hazardous waste should be established before the construction of the facility.
- Detailed emergency plans for spillages and disasters at the facility as well as on the access road must be developed before the operation phase.
- A policy on temporary storage should be developed before storage of waste, where no treatment plan has been established.
- Only one construction camp should be developed for the facility to reduce potential impacts.
- The development of the hazardous waste facility should be accompanied by a overall development/land use plan for the surrounding area to ensure that any

potential future conflicts regarding land use inherent in future projects in the area are identified and mitigated as quickly as possible.

- A zoning plan should be developed for the area around the hazardous waste facility that takes into consideration the requirements of local communities and provides a vision of what types of development shall be permitted in future.
- A comprehensive compensation and resettlement plan should be developed for the project as soon as possible. Compensation and resettlement should be handled with the highest degree of sensitivity and the project should avoid, in the planning phase, compensating or relocating people who have already been relocated due to other projects.
- Resettlement plans should not be limited to simple land attribution but include support to the local population in relationship to land clearance, seed stock and agricultural extension services, in accordance with World Bank guidelines on compensation and resettlement.

Conclusion and recommendations for the Access Road

Surfacing of the Access Road:
It is recommended that alternative 2: Emulsion stabilised sand road be used for the access road. This will ensure improved vehicular safety and less noise with no dust. This alternative will have the following benefits:

- Dust associated with gravel roads, that could influence the health of persons living next to the road will be limited.
- Dust associated with gravel roads, that could reduce crop production and/or influence the quality of the crops will be limited.
- Noise associated with gravel roads will be reduced.
- Road safety will increase for the safe transportation of waste, decreasing risk of spillages and environmental damage.

Early Access Road:

It is recommended that the early access road not be considered as an alternative and that the alignment chosen for the permanent access route also be utilized for the early construction access route. By following the same alignment, potential environmental and social impacts are minimized and concentrated along a single axis rather than distributed and duplicated.

Route Alignment for the Access Road

The Moamba – Boane route alternative has less social cost associated with the route, but much higher impacts relating to transportation cost and the potential for spillage and major environmental disasters.

The Motraco route alternative does have social implications relating to relocation and compensation for machambas in terms of loss in income, relocation cost as well as loss of prepared machambas. Mitigation measures to deviate around formal machambas, that have already been relocated during the implementation of the Mozal project and around a low laying marshy area, ensures that the social cost associated with relocation is not of high significance.

It is clear that the social cost associated with the Motraco route alternative is outweighed against the environmental risk and escalating transportation cost of the Moamba-Boane road. It is therefore recommended that Alternative 2 following the Motraco transmission line with two deviations is the preferred alternative for the proposed access road.

Alternative 3 should be investigated in much more detail if this option is to be considered in the future.

It is quite evident from the environmental assessment, with specific reference to the detailed specialist studies and the social studies that the selected Mavoco site for the establishment of the hazardous waste treatment facility, and the access road have certain definite opportunities and constraints. The ultimate purpose of this analysis and evaluation process is to ensure that the constraints do not out weight the opportunities, and that the "allowable" environmental and social constraints / costs of the project do not compromise the existing social and environmental integrity. Within this framework the following conclusion is made - The site is suitable for the proposed development, providing the above recommendations is taken into consideration.

It would be imperative to finalise the results of the above to provide full confidence of the long term sustainability of the facility.

1 PROJECT BACKGROUND AND INTRODUCTION

1.1 Project Background

In Mozambique, as in the majority of developing countries, solid waste management is a growing environmental, socio-economic and public health problem. Municipalities face difficulties in the management of the increasing volume of waste produced by industries and the population.

The growth of the Mozambican economy in the last couple of years has also implicated a growth in industrial production. Industrial waste production is increasing and the wastes are disposed-off on the premises of the factories, or in "dumping sites" that were not authorised by the municipalities, as well as in municipal waste dumps. None of these disposal sites and methods have been established according to norms and regulations for industrial/hazardous waste disposal. This situation poses a risk not only to the environment but also to the health of workers involved in waste handling, as well as to the general public.

Maputo City and Maputo District are experiencing a considerable increase in socio-economic development, to which the current population growth, urbanisation and industrialisation are associated. These factors contribute to a change in the pattern and quantity of solid waste produced in the region. Maputo City and Maputo Province do not have adequate facilities for the elimination of municipal and industrial solid waste. With the development of the Mozal aluminium smelter and the consequent establishment of the Beluluane Industrial Area (proposed to deal with 2nd order waste from Mozal), hazardous waste production in the province has increased dramatically. At present this hazardous waste from Mozal is stored in a temporary storage area on site, but this storage area will reach capacity in future.

The Beluluane Industrial Area is ideally situated due to accessibility from the highway to South Africa and the Matola harbour area. It represents 660 hectares of land around Mozal that is available for industrial development. At least 80% of the industrial area will be operated as a Free Trade Zone to attract investment into the area by allowing companies a tax haven. The expected investment will include companies providing services to Mozal, downstream aluminium manufacturing, manufacturing plants such as automotive plants, light manufacturing, other servicing and value adding industries, training providers and professional service providers.

These developments necessitated the development of a hazardous waste landfill site for the safe disposal of waste from Maputo City, Mozal, other industries and the rest of Mozambique. Such a facility would enhance the attractiveness of the area for investors and ensure the well being of those around the site by providing a facility where waste that is classified as hazardous to human health or the environment can be safely disposed of. Currently no such facility exists in Mozambique.

1.2 History of Site Alternatives and Site Selection Process (Source: Seed, 2001)

MICOA identified 3 areas to be evaluated for the potential development of a hazardous waste landfill site and 2 additional sites were added during the investigation. These sites were Boquisso (Matola district approximately 31km from Maputo), Beluluane (close to Motraco substation near Mozal approximately 27km from Maputo), Mavoco (along the powerlines to South Africa 7 km from Motraco substation near Mozal approximately

34km from Maputo), Highway (adjacent to highway to South Africa 5 km from Matola river bridge) and Namaacha (close to the Swaziland border approximately 54km from Maputo).

A consultant was appointed by MICOA to investigate the feasibility of developing the site at these predetermined positions. Each of the sites were assessed and ranked according to socio-economic, biophysical and public consultation criteria using a rating matrix. The following criteria was used to determine the most suitable site: land use planning, land occupation density, use of natural resources, need for displacement, cultural aspects, public health, distance to the site from industrial activities, Maputo and other potential client areas, accessibility, protection of species and habitats and limited public consultation.

The site Mavoco, with the following references was ranked the most favourable and was well accepted by the local community. This finding was recommended by the consultant to MICOA to allow the development of the site at Mavoco and was accepted by MICOA:

Points	Latitude	Longitude
A	25 52' 15.5" S	32 18' 55.5" E
B	25 51' 56.4" S	32 19' 07.3" E
C	25 52' 06.7" S	32 19' 30.0" E
D	25 52' 27.5" S	32 19' 17.5" E

It is important to note that the Beluluane B site referred to in the Seed, 2001 document, was renamed to the Mavoco site. The Seed, 2001 document also refer to the Beluluane A site that is known in this report as the Beluluane site.

1.3 Criteria Used in the Site Selection Process (Source: Seed, 2001)

Description of criteria used in the original site selection and ranking process:

- **Land Use Planning** - the location of major projects identified for the study area and the distance between the proposed airport and proposed hazardous waste landfill site.
- **Land Occupation Density** - the number of houses found within the study area.
- **Natural Resource Use** - the use of the natural resources such as firewood, hut construction material, food and handcraft by the local inhabitants.
- **Need for displacement of people**, properties and services due to the placement of the proposed hazardous waste landfill site.
- **Aspects with cultural, historic and archaeological value** - any sites with value are assessed.
- **Human Health** - the potential of water contamination is assessed and the analysis of wind direction for dispersing of gas.
- **Distance to be covered and access roads** between the hazardous waste landfill site and the industries to be serviced.
- **The presence of protected species** and habitats was assessed and rated.
- **Public Participation Process objectives** were to ensure that the public understood and accepted the criteria for site selection and to create awareness in order to guarantee approval for the criteria used for the final selection.

Each criteria was scored and calculated as follows:

1. Very Bad
2. Bad
3. Reasonable
4. Good
5. Very Good

Table 1. Ranking Matrix

CRITERIA	BOQUISSO	BELULUANE	MAVOCO	HIGHWAY	NAMAACHA
Land use planning	1	5	**5**	4	3
Land occupation density	1	2	**3**	2	4
Use of natural resources	1	1	**2**	2	3
Need for displacement	1	2	**2**	2	3
Cultural Aspects	1	3	**5**	3	5
Public Health	1	2	**3**	3	3
Distance to site	3	4	**4**	3	2
Access roads	3	2	**4**	3	2
Protected species or habitats	4	4	**3**	3	4
Public participation	N/A	2	**5**	N/A	1
TOTAL SCORE	16	27	**36**	25	30

1.4 Appointment of Africon

After a regional tendering process, where national and international consultancy enterprises participated, Africon was appointed by MICOA to conduct the EIA on the chosen site and access route and to review the engineering design. The EIA will focus on the social and environmental risks of the chosen site, as well as alternatives for the access route.

The development of Mozal and the surrounding industrial area required the resettlement of some communities that previously occupied the area. The aim of this PPP and EIA is to find the best alternative access route alignment to the chosen site with minimal environmental and social impact and to record all potential impacts and propose mitigation for the development of the site itself.

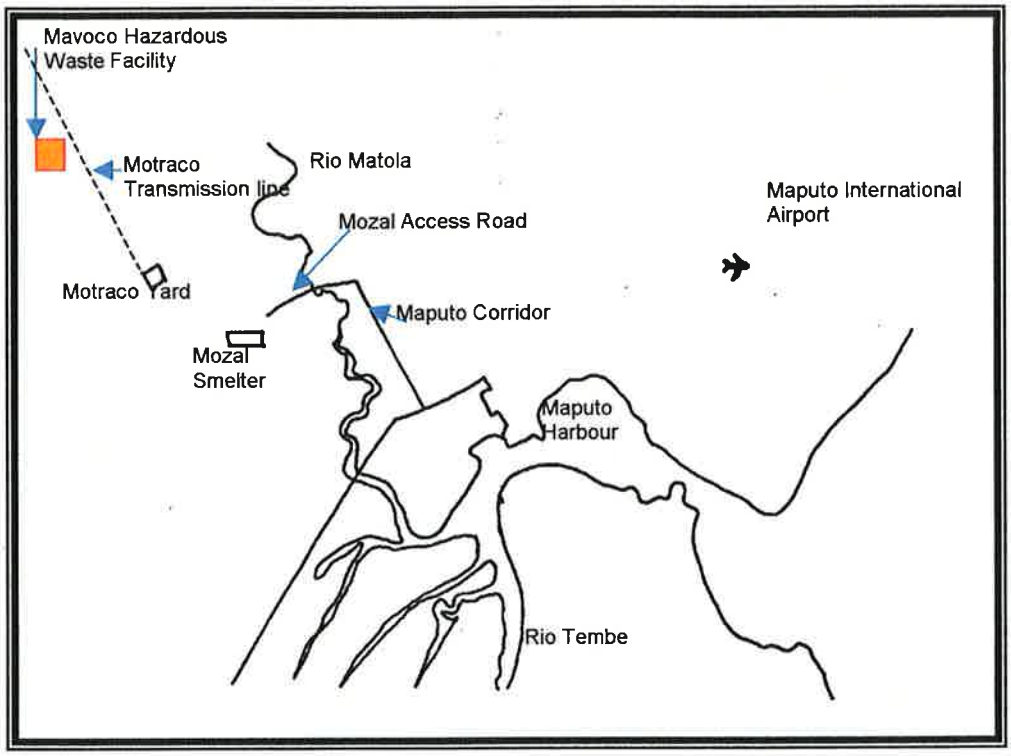
The EIA will be conducted in accordance with the principles established by the Decree No 76/98 of 29th December 1998 entitled "Regulation of the Process of Environmental Impact Assessment" and other national and international regulatory definitions applicable to this exercise.

In keeping with the requirements of the above-mentioned Regulation, the study will observe the steps presented in the flow chart inserted in Section 6 of this document.

2 PROJECT DESCRIPTION

2.1 Location of the Proposed Site

The site is located in the Beluluane area, approximately 6km north-west from the Motraco power station and 10 km west-north-west of the Mozal Smelter. The site lies east of the road between Moamba and Boane, east of the Xingube River and approximately 33km from Maputo city.



Mavoco Hazardous Landfill site – Location Plan.

The site is located in the Matola-Rio Administrative Post, in Boane District and integrates the Mavoco quarter. This is one of the quarters that together with Tchonissa, form the Mulotane settlement.

2.2 Description of Activity, Site and Surroundings

The components of the waste facility will comprise of the following; one landfill cell with operational dividing bund walls, a leachate buffer and management system, temporary waste storage system, access road, weighbridge, operational hard surfaced areas, administration buildings/workshops, laboratory, waste stabilization unit, fire protection system, borehole water supply, sewage systems, fencing, power and lighting supply and a telephone system.

The regional area surrounding the site is very much rural in nature and character. The settlement pattern is dispersed and informal, indicative of no structured planning. The communities resettled from the Mozal development area are located in two "formally" structured Machamba areas namely; Beluluane and Mavoco. These two areas have

been formally established on a grid basis and are clearly identified from the aerial photographs (See figures 3-8). The larger areas between these two structured "Machamba" areas are informal in-fill of "Machambas" with clearly no structure.

A new access road is to be constructed to the facility. The alternatives proposed for the access road that follows the Motraco electrical line which transects this area where the resettlement of "Machambas" or plots, have taken place and this will have to be taken into account when evaluating the route alignment.

The proposed site is north west of all the formal "machamba" areas. It is covered with predominantly natural vegetation with isolated and dispersed informal "machambas".

2.3 Phasing of Construction and Development of Site

The total site is 50 ha in extent. An initial 10 ha are required for the establishment of the facility infrastructure, and sufficient landfill capacity for the first 10 years of disposal. The initial establishment would involve a 5-year cell, plus 10-year infrastructure with provision for future expansion to a 20-year capacity.

The plant shall be designed to facilitate reliable and continuous operation, as well as easy accessibility for operation, maintenance, equipment replacement, handling, cleaning and inspection. All equipment supplied and installed shall be designed to ensure satisfactory operation under the atmospheric, ambient and other conditions prevailing at the site.

2.4 Expected Waste Types and Quantities

The following waste types and quantities is expected to be catered for at the proposed facility:

WASTE TYPE	Estimated Quantity (tons per annum)
From Mozal	
Fluorinated objects (bags, green poles, refractories)	360
Fluorinated waste material (shot blasting material, white product etc.)	4440
Small quantity of high hazard wastes (fluorescent tubes, batteries, organic solvents, mercury waste)	2
Pitch sludge/waste	30
Oil contaminated waste	168
Sub-total	**5000**
Rest of the country	
Organic chemical wastes (total sulphur and /or halogens exceeds 1%)	54
All organic solvents (without halogens and sulphur)	53
Waste that can be incinerated (and that does not fall into the other categories)	16
Inorganic acids, bases, salts and heavy metals	724
Reactive wastes	274
Compounds and materials requiring special and extensive treatment	270
Approximate Sub-total	**2200**
Total waste stream to be catered for	**7200**

See appendix A for a detailed list of the waste streams produced at Mozal as well as a list of all the different types of waste produced in the rest of Mozambique.

The proposed facility will be designed to cater for most of the known hazardous waste produced in Mozambique and in particular the waste from Mozal that is estimated to produce the most waste, percentage wise. Unidentified / new types of waste that could not be treated at this facility would be stored on the site until studies have been undertaken to establish the treatment procedures. This waste cannot be stored indefinitely and a reasonable time period will have to be determined and procedures stipulated for the treatment of this waste stream at another facility.

2.5 Planning approach principles to the hazardous waste management

Solid Waste Disposal

Landfills are managed disposal sites, which entail the burial of waste in the ground. Most other forms of disposal are either environmentally unacceptable or too expensive for most waste. Urban and industrial waste, though low in total output compared to agricultural and mining waste, presents the most problems to land use planning. There are several factors, which account for this, such as groundwater contamination and public health, the growing concern over surreptitious hazardous waste, the conflict over aesthetic and real estate values, the limited availability of land around cities for waste disposal, and the high costs of collection and transportation. In addition the production of hazardous and domestic waste has been increasing in all parts of the world.

Site Selection Criteria

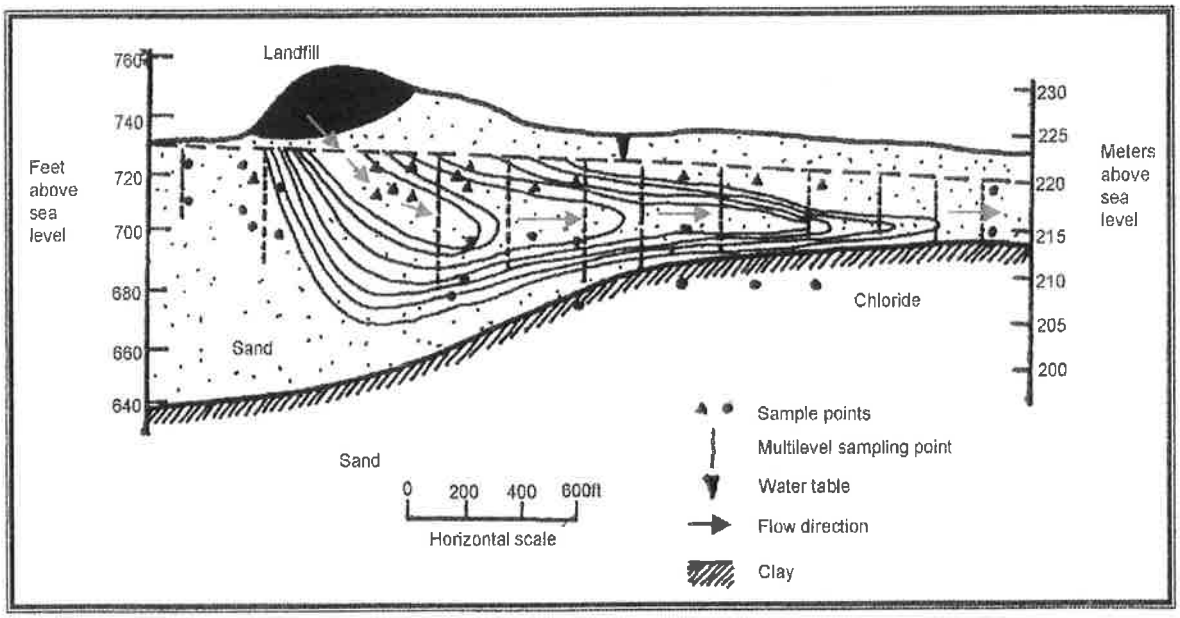
The selection of a disposal site for urban and industrial waste is one of the most critical planning processes faced in suburban and rural areas today. Properly approached, it should be guided by three considerations:

- Cost, which is closely associated to land values and transport distances;
- Land use and environment, in the vicinity of the site and along transport routes;
- Site conditions, a function of soil, drainage and permeability.

In both urban and industrial disposal the largest concern is the liquids that emanate from the decomposing mass of waste.

These fluids are collectively known as leachate and are composed of heavy concentrations of dissolved compounds that can contaminate local water supplies. Leachate is chemically complex and varies in makeup according to the composition of the refuse. A further significant constraint is the fact that the behaviour of leachate in the hydrological system, especially in ground water, is poorly understood. Therefore the general rule in landfill management is to restrict leachate from contact with either surface or subsurface water. Instances of groundwater contamination by leachate typically results in the loss of potable water for many decades.

The following shows an example of a leachate plume emanating from a landfill, where the plume travelled 2200 ft over 35 years, contaminating local groundwater to a depth of 40-80ft



Example of a leachate plume

Management Planning

Management plans for the design and operations phases of landfills are statutory requirements of many state and provincial authorities. Certain of the planning requirements are:

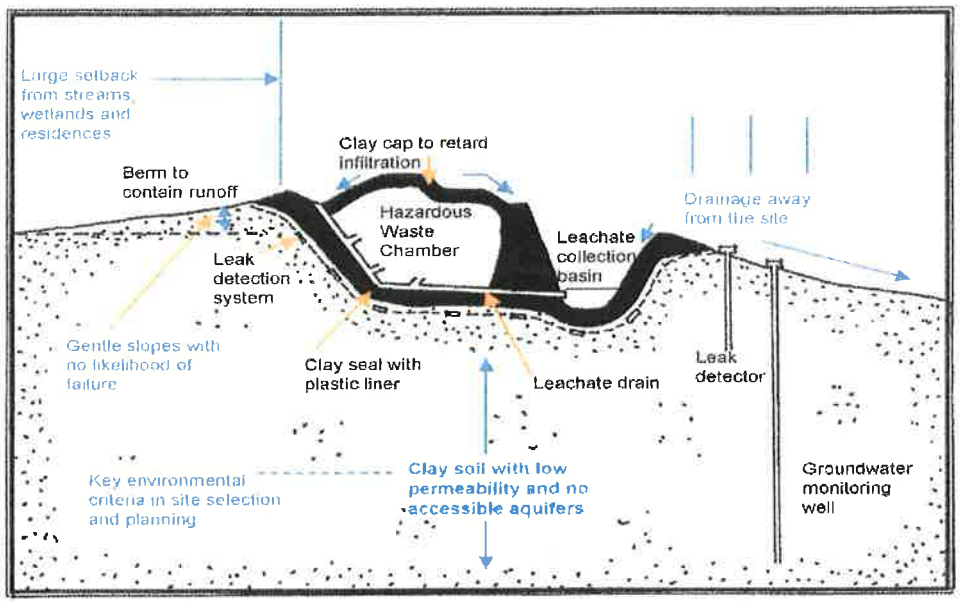
- Compartmentalisation of the landfill into cells or self-contained units.
- Phasing of the operation, excavation and filling of a limited area at any one time.
- Landscaping, pest control, and protection of the site during operations.
- Limiting the total thickness of the refuse by interspersing the layers with soil.
- Backfilling the completed fill using a layer of soil with the provision of vent pipes if required.
- Preparation of a plan for grading, landscaping, and future use of the site.

Waste disposal versus Treatment

Several strategies are available for managing hazardous waste. They fall into two classes; disposal and treatment. *Disposal* entails the collecting, transporting and storing of waste with no processing or treatment. *Treatment* involves submitting the waste to some sort of processing to make it less harmful. Due to the increase in awareness and control of public health and safety requirements, as well as local land use and public opinion problems, land disposal has become a very costly undertaking. For this reason, amongst others, the trend is towards on-site treatment.

Secure Landfill

The most widely used landfill disposal method is the secure landfill. The objective of this method is to confine the waste and prevent it form escaping into the environment from the disposal site. The first step in selecting a landfill site is the selection of the appropriate site based on the selection criteria. Site selection is followed by landfill design.



Environmental criteria and design features of a secure landfill site according to current standards in the United States

2.6 Typical Waste Handling Process (See the following diagrams)

The proposed waste treatment and storage facility will be developed primarily to cater for the waste stream from Mozal, and for the anticipated hazardous waste stream from within Mozambique. Due to the varying nature of such a waste stream, the proposal is to build a higher order engineered hazardous waste landfill facility - a so called H:H classed facility according to regionally and internationally acceptable standards.

According to the adopted South African design regulations, Hazardous Waste may only be disposed of at a landfill designed specifically for the disposal of Hazardous Waste. The so called H:H landfills can accept all wastes that are allowed to be landfilled while H:h landfills are not as stringently designed.

The engineered landfill at Mavoco will be a containment structure built essentially from excavated clayey materials thus creating a bathtub effect and lined with synthetic products and constructed clay layers to ensure an impervious liner below and on the sides. The waste will be treated prior to landfilling and the proposed method of pre-treating the waste by blending it with cement is viewed as one of the internationally acceptable methods to dispose of the waste, provided it is done under controlled conditions according to an operational environmental management plan.

Control of the waste stream would be required at all times from where it is collected at the source and transported to the landfill facility. Proper transportation equipment and vehicles would be required to convey the waste to the landfill and which will be travelling on a durable and surfaced roadway. The intention is to limit the possibility of any spillage of the waste on-route to the waste disposal facility.

Proper control of the waste entering the facility is planned with the use of a guardhouse, control room and weighbridge facility. This is of utmost importance to the successful management of the landfill as each waste type requires specific treatment prior to landfilling or temporary storage. Correct treatment is considered necessary as chemical reactions could develop with negative impacts on the environment.

The proposed approach for the design of the new Mavoco Hazardous Waste Facility is to establish a Temporary storage and Handling Facility for the small quantities of

problematic waste that cannot be landfilled directly due to its chemical nature. Such waste would be stored until such time as there is sufficient quantity to warrant exporting for safe destruction, or to establish onsite treatment facilities. It is possible that small scale pre-treatment such as acid/alkali neutralisation could be conducted in the Temporary Storage Facility.

The majority of the waste stream will comprise of fluorinated waste products from Mozal that require cement or lime stabilization to immobilize the fluoride in the waste. A Blending or Stabilisation Facility is therefore planned for the site. In this facility the fluorinated wastes can be blended with cement or lime prior to disposal in the landfill cells. The intention is also to allow for ash blending of liquid wastes such as oily sludges and tannery wastes at the blending facility.

The prime objective of immobilisation techniques is to convert the Hazardous Waste into an inert, physically stable mass. This treated waste should have a very low leachability and sufficient strength to allow for landfilling or land reclamation. Immobilization (or chemical stabilisation) is a process in which the waste is converted to a more chemically stable or more insoluble or immobile form. The most common materials used are cementing agents, such as Portland cements, lime, fly-ash and gypsum mixtures.

Landfill-ash blend involves the mixing or blending of a flammable waste with sufficient fly-ash, bottom ash or other material, so that the flash point is >61°C. Ash blending is considered a treatment process. The resulting product may be landfill co-disposed with General Waste in accordance with its Hazard Rating. Neutralisation is the addition of acid or alkali to bring the pH in the region of 7. Lime is normally used to neutralise acid wastes prior to landfilling. Precipitation is the addition of lime, sodium sulphide or other reagents that result in the formation of insoluble substances that come out of solution.

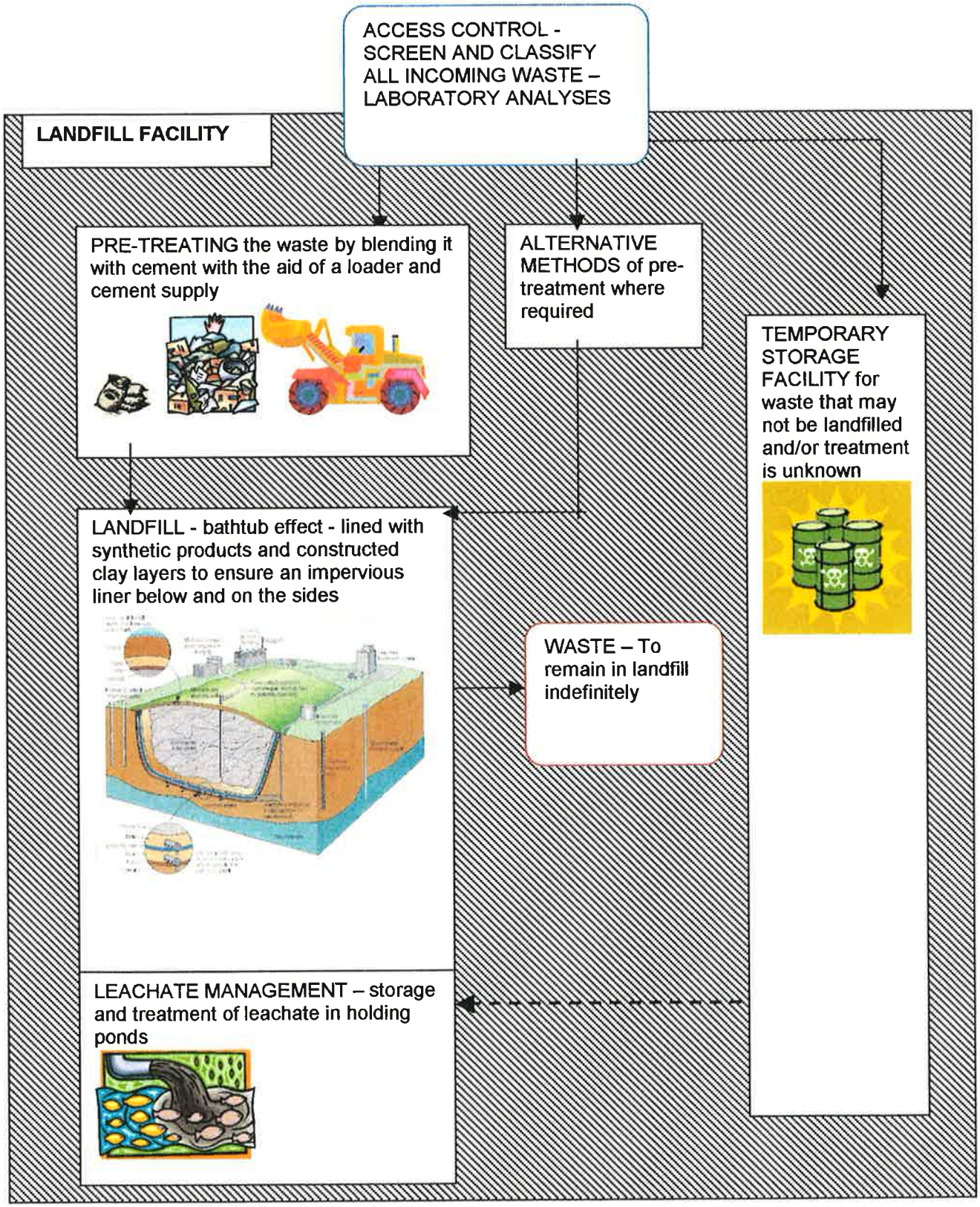
Once the waste is landfilled the contaminated liquids that will leach through the waste as a result of the liquids in the waste or in most cases rainwater, called leachate, will have to be managed and treated. Any other water that has indirectly been exposed to the waste also has to be managed and treated prior to discharge back into the environment. The management of the leachate and contaminated water is planned by providing storage ponds and to either spray irrigate the leachate over the landfill with the intention to minimize the leachate through evaporation.

Part of the landfill design is a liner system consisting of a leachate collection system (plastic pipe network), compacted clay layers, geomembranes and geotextiles to prevent the ingress of contaminants and contaminated liquids into the ground thus preventing the pollution of the groundwater regime.

Mess, ablution and office facilities as well as safety systems are to be allowed for as part of the development of the landfill.

When the available landfill volume is exhausted and built up to the designed height and capacity, the landfill is covered and rehabilitated to an environmentally acceptable state.

HAZARDOUS WASTE MANAGEMENT FACILITIES



HAZARDOUS WASTE MANAGEMENT PROCESS

Mozal Aluminium Smelter production process generates hazardous waste

Hazardous waste generated elsewhere in **Mozambique**

INCOMING WASTE
- Fluorinated waste material (shot blasting material, white product etc.)
- Fluorinated objects (bags, green poles, refractories)
- Small quantity of high hazard wastes (fluorescent tubes, batteries, organic solvents, mercury waste)
- Pitch sludge/waste
- Oil contaminated waste

INCOMING WASTE
- Organic chemical wastes (total sulphur and /or halogens exceeds 1%)
- All organic solvents (without halogens and sulphur)
- Waste that can be incinerated (and that does not fall into the other categories)
- Inorganic acids, bases, salts and heavy metals
- Reactive wastes
- Compounds and materials requiring special and

ACCESS CONTROL - SCREEN AND CLASSIFY ALL INCOMING WASTE – LABORATORY

LANDFILL FACILITY

PRE-TREATING the waste by blending it with cement with the aid of a loader and cement supply

ALTERNATIVE METHODS of pre-treatment where required

TEMPORARY STORAGE FACILITY for waste that may not be landfilled and/or treatment is unknown

LANDFILL - bathtub effect - lined with synthetic products and constructed clay layers to ensure an impervious liner below and on the sides

WASTE – To remain in landfill indefinitely

LEACHATE MANAGEMENT – storage and treatment of leachate in holding ponds

NATURAL ENVIRONMENT – WATERCOURSE. Only when treated leachate has reached the accepted standards may water be discharged into watercourse.

2.7 Site Facilities and Design Lifetimes of Facilities for Hazardous Waste

The planning of the landfill facility was considered for a period lasting 20 years. All planning of the infrastructure associated with the facility should therefore have a sustainable lifespan of 20 years. However, due to normal maintenance requirements the proposed infrastructure would be refurbished after 10 years with the possibility of including improvements depending on the required developments at the facility.

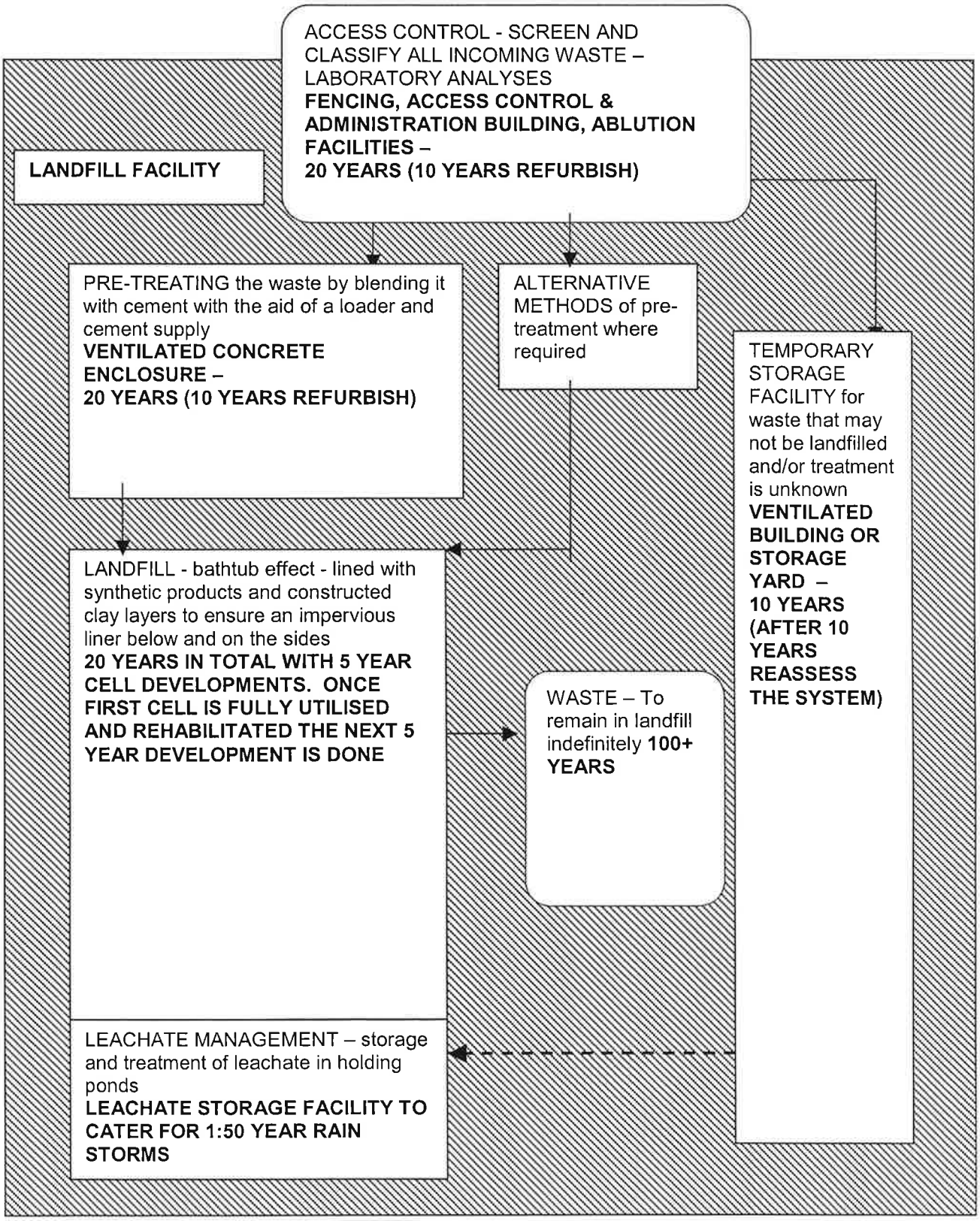
Due to the changing environment in the management of hazardous waste it is considered feasible and practical to base the detailed designs of facilities of this nature on periods of 5 years, although the entire facility has been planned based on a 20 year lifespan i.e. provision has been made for future expansion. One of the main reasons in following this approach is the potential for damage, caused to sections of the facility not in use, where they are constructed to far in advance. Desiccation and natural weathering of the sensitive materials such as liners will occur if left unattended for long periods. Prior to the depletion of the available landfill cells additional cells have to be prepared to offer a continued service once the first period has expired. This process would be repeated for the following periods until the lifespan of 20 years has expired.

The temporary storage facility for unknown waste products has been designed with a 10-year lifespan only. Once this period has expired the facility will probably have to be reconstructed to a large degree or a new approach to the storage of unknown waste products will have to be adopted.

Facilities such as the stormwater drains and ponds as well as the leachate ponds are designed to deal with the receiving waters in events such as rainstorms with severity and recurrence intervals of once in 50 years. Although the landfill facility is only prepared to receive waste over a period of five years the required associated facilities such as the leachate holding ponds as well as the contaminated water ponds are constructed to service the site for 20 years and beyond, provided the necessary maintenance is done.

Once the waste has been stored or deposited at the landfill facility it is expected to remain there indefinitely (100 years +) unless physically removed. Monitoring of this waste body for environmental impacts would then become the responsibility of the owner of the facility or assigned responsible person or body.

SITE FACILITIES AND DESIGN LIFETIMES OF FACILITIES FOR HAZARDOUS WASTE



3 LEGAL AND INSTITUTIONAL REVIEW AND INTERNATIONAL PRACTICE

3.1 International Waste Management Practice

In the past 15-20 years, increasing attention has been given to the impacts on health and to the environmental significance of chemical contaminants in wastes. This is for the most part due to an increasing awareness that improper disposal of such wastes has resulted in significant adverse health and environmental consequences. Unfortunately the awareness had to be triggered by actual or potential disasters, most of which are well documented in relevant literature. Such disasters, as well as uncontrolled dumping of hazardous waste, were subsequently addressed by international organisations, mostly under the auspices of the United Nations.

In 1983, the United Nations Environment Program (UNEP) in conjunction with the World Health Organisation (WHO) published principles for the formulation and implementation of a hazardous waste management policy, as a code of practice. In 1985, under the auspices of UNEP, the "Cairo Guidelines" on policies and legislation for the environmentally sound management of hazardous substances were adopted. Also in 1985, an International Register of potentially toxic chemicals, with treatment and disposal options for hazardous waste, was published by UNEP. In 1986, guidelines, policies and strategies for hazardous waste management in Asia and the Pacific were published by UNEP. The UN Economic Commission for Europe started to focus particularly on low-waste and non-waste technologies in the later parts of 1980-1990. The Basel Convention, to which Mozambique is a signatory, on the Control of Transboundary Movements of Hazardous Waste and Their Disposal came into force on 5 May 1992.

In the UK, a waste management licensing system came into force in April 1993. This specifies that any residual pollution risk posed by a completed landfill is borne by the operator until the site has stabilised. Post-closure and other costs will therefore have to be paid by the operator. New hazardous waste management plans are currently being drafted by, amongst others, Hungary, The Netherlands, Japan, Denmark and France. In addition, the Working Group on Hazardous Waste (WGHW) of the International Solid Waste Association (ISWA) has agreed to the following 10 priority work areas for fiscal years 1994-1997.

1. Household hazardous waste and small generators;
2. Contaminated sites
3. Developing countries
4. Safe or best hazardous waste practices
5. Household waste transport
6. Waste minimization
7. Siting issues
8. Socio-economic issues;
9. Hazardous waste handling; and
10. Industrial waste

3.2 International Definition of Hazardous Waste

Considerable attention has been focused on the question of what constitutes a "Hazardous Waste." National systems differ both in the methods used for defining wastes and in the type of wastes included. These differences arise partly from variations in the institutional and legal frameworks of different countries and partly from the difficulty

involved in distinguishing between wastes that are "normal" and wastes that are Hazardous.

The South African definition of Hazardous Waste is based upon the UNEP definition, "Waste, other than radioactive waste, which is legally defined as hazardous in the state in which it is generated, transported or disposed of. The definition is based on chemical reactivity or toxic, explosive, corrosive or other characteristics which cause, or are likely to cause, danger to health or to the environment, whether alone or in contact with other waste." Internationally, many different "legal" definitions for hazardous waste exist. In most cases the definitions are relatively vague and mostly refer to a list of compounds and/or types of wastes concerned.

Some of the main identification criteria for such lists are:

- Type of hazard involved (flammability, corrosivity, toxicity, reactivity);
- The generic category of the products involved (e.g. pesticides, solvents, medicines);
- Technological origins (e.g. oil refining, electro-plating);
- Presence of a specific substance or group of substances (e.g. PCB, dioxin, lead compounds).

3.3 SADC Regional Legal and Institutional Review

The development of a hazardous waste landfill at Mavoco is governed by the following legislation, protocols, guidelines, white papers, etc. Legislation from neighbouring countries are shown to highlight the regional development.

Mozambique:	Enabling legislation and Article 8.3 of the Environmental Impact Assessment Regulations approved by Decree no. 76/98.
South Africa :	Environmental Conservation Act, (Act No. 73 of 1989), EIA Regulations, R 1182 and 1183 of 1997 and the National Environmental Management Act (Act No. 107 of 1998).
Swaziland :	Environment Authority Act, 1992. The Environmental Audit, Assessment and Review Regulations 2000 and The Waste Regulations 2000.
Botswana :	Waste Management Act 1998.
Zimbabwe :	Enabling legislation
Zambia:	Environmental Protection and Pollution Control Act 1990, Regulations 1997.

3.4 Mozambican Legal and Institutional Review

Relevant legislation applicable in the Republic of Mozambique:

- **Constitution of the Republic of Mozambique**, approved on November 2nd 1990:

The Articles 37 and 72 of the Constitution determine the general policies and principles guiding the protection and preservation of the environment, including:

- Article 37: The State promotes initiatives to ensure the ecological balance and the conservation of the environment, in order to improve the living standards of its citizens.

- Article 72: Every citizen has the right to live in a balanced environment, and it is his/her duty to protect it.

- Resolution 5/95, dated August 3rd – "***Política Nacional do Ambiente***" **(National Environment Policies)**:

This is the legal instrument through which the Government recognizes the interdependency of "development" and "environment". It leads to the implementation of social and macroeconomic policies that might be acceptable from an environmental perspective, with the objective of promoting and boosting the economic growth based on universal principles of self-sustained development.

The National Environment Policies establishes the overall guidelines to be complied with by the Government, and by all public or private institutions, whenever dealing with environmental issues.

Above and beyond the approval of the "*Lei do Ambiente*" – Environment Act- one of the legal priorities resulting from the agreed Environmental Policies, is the completion of regulations and rules, including the definition of water quality standards, domestic residual waters and its recycling process, toxic waste, air and soil quality, etc. The Government is giving special attention to the environmental issues, and in particular to its enforcement.

- Law 20/97, dated October 1st - ***Lei do Ambiente*** **(Environment Act)**:

  This act establishes the legal grounds for the correct use and management of the environment and its components. It only defines the fundamental principles to be observed and it must be complemented with specific regulations and rules.

The act defines **Hazardous Wastes** - "***Lixos ou Resíduos Perigosos***"**-** as substances or objects which are disposed of, or are intended to be disposed of, or are required by law to be disposed of, and which are inherently dangerous because they are inflammable, explosive, corrosive, toxic, infectious or radioactive, or due to any other inherent characteristic that might represent a risk to the life or health of people and/or other life-forms, or might adversely affect the environment.

- Decree 76/98, dated December 29th – "***Regulamento sobre o Processo de Avaliação do Impacto Ambiental***" **(Environmental Impact Assessment Regulations) and**
- **General directives regarding Environmental Impact Assessments,** July 2000:

These regulations specify the procedures and steps to be observed whenever an Environmental Impact Assessment is to be carried out and specify the licensing of consultants responsible for the administration of the process. The EIA process is the basic step for an environmental licensing to continue with a proposed development.

Until national standards are adopted, the evaluation criteria to be complied with should be those standards approved by international organisations, including those standards established by international conventions ratified by Mozambique.

- Law 8/98, dated July 20th - ***Lei do Trabalho*** **- Labour Law** (Chapter IV):

Chapter IV (articles 146 to 165) of the above referred Law, refers the conditions regarding the Workers Hygiene, Safety and Health. These articles define the rights of

the workers and also the rights of their respective employers. However, it is necessary to complement this piece of legislation with specific rules regarding each sector.

- Resolution no 18/96, de 26 de Novembro - ***Convenção de Brasília sobre o Controlo de Movimentos Transfronteiriços de Resíduos Perigosos e a sua Eliminação.*** **(Basel Convention regarding the Control of Transboundary Movements of Hazardous Wastes and their Disposal)**

- Resolution 19/96, dated November 26th - ***Convenção de Bamako relativa à Interdição da Importação de Lixos Perigosos e ao Controlo da Movimentação Transfronteiriços desses lixos em África*** **(Bamako Convention regarding the Interdiction of Importation of Hazardous Wastes and the Control of Transboundary Movements of Hazardous Wastes in Africa)**

According to information provided by MICOA, the Regulations regarding the Management of Hospital Waste and the Management of Industrial Waste are expected to be approved soon.

Central Government will only approve generic legislation with regard to Urban Waste, if it defines the guidelines to be followed by the each city council, in their responsibility to formulate regulations in accordance with the specifications of the waste produced in each area.

3.5 International Protocols

Basel Convention, March 1989

Guidelines entitled "Establishment of a Technical Working Group to Elaborate Technical Guidelines for the Environmentally Sound Management of Wastes subject to the Basel Convention" were undertaken in accordance with Resolution 8 as adopted during the Conference of Plenipotentiaries on the **Global Convention on the Control of Transboundary Movements of Hazardous Wastes** (Basel, March 1989). The following from these guidelines have relevance:

Whilst waste disposal has clearly been practiced in various forms for millenniums, waste management is a much more recent activity. Indeed, even in industrially developed countries, legislation specifically addressing waste disposal has only emerged over the last 20 years. Controls prior to that were of a more general nature, related perhaps to public health issues or land-use planning. Waste management is a much more recent activity which is designed to identify and manage wastes throughout their entire life cycle with a strong emphasis in reduction, re-use and recycling activities.

Although the term 'Hazardous Waste' is often used in a loose and non-specific sense, the Basel Convention provides a classification of the categories of waste to be controlled. The Convention further provides that it should include as hazardous waste any wastes defined as, or considered to be hazardous waste by the domestic legislation of the Party of export, import or transit. Environmentally sound management of waste is also described within the Convention, and is stated as being the 'taking of all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such waste'.

Environmentally sound management is defined in the Basel Convention as taking all practicable steps to ensure that hazardous waste or other waste are managed in a

manner, which will protect human health and the environment against adverse effects, which may result from such waste.

In this context, the criteria to assess environmentally sound management include the following:

(a) Regulatory infrastructure and enforcement exists that ensures compliance with applicable regulations;

(b) Sites or facilities are authorized and are of an adequate standard of technology and pollution control to deal with the hazardous waste in the way proposed, taking into account the level of technology and pollution control in the exporting country;

(c) Operators of sites or facilities at which hazardous waste are managed are required, to monitor the effects of those activities;

(d) Appropriate action is taken in cases where monitoring indicates that the management of hazardous waste have resulted in unacceptable emissions;

(e) Persons involved in the management of hazardous waste are capable and adequately trained in their capacity.

Countries also have obligations to avoid or minimize waste generation and to ensure the availability of adequate facilities for their waste, so as to protect human health and the environment.

In this context, countries should, *inter alia*:

(a) Take steps to identify and quantify the types of waste being produced nationally;

(b) Use best practice to avoid or minimize the generation of hazardous waste, such as the use of clean methods;

(c) Provide sites or facilities authorized as environmentally sound to manage its waste, in particular hazardous waste.

In addition, enforcement and monitoring could be enhanced through international cooperation.

New facilities

Establishment of new production facilities should be designed taking into consideration criteria for the application of cleaner production techniques.

Categories of Waste Streams to be controlled:

The Basel Convention provides lists (see appendix B) of Waste Streams and describes the characteristics of hazardous substances.

3.6 Minimum requirements (DWAF)

3.6.1 The South African Department of Water Affairs and Forestry: Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste

The Department of Water Affairs and Forestry of South Africa has published minimum requirements for the handling, classification and disposal of hazardous waste in 1998. The following is a short summary of these requirements:

A Hazardous Waste or waste stream may consist of any number of different substances and compounds. In accordance with the Precautionary Principle, it is the most hazardous substance and its concentration that determines the class, the Hazard Rating and the ultimate method of disposal of a waste or waste stream.

Treatment: Since a single substance can determine the Hazard Rating, treatment can be used to reduce the hazardousness of the substance. Thereafter the next most hazardous substance will determine the Hazard Rating.

Hazard Rating: The Hazard Rating is used to classify Hazardous Waste into four Hazard Ratings.

- Hazard Rating 1 (Extreme Hazard): is waste of first priority concern, containing significant concentrations of extremely toxic substances, including certain carcinogens, teratogens and infectious waste.
- Hazard Rating 2 (High Hazard): is waste of second priority concern with highly toxic characteristics or extremely toxic substances, which are not persistent, including certain carcinogens.
- Hazard Rating 3 (Moderate Hazard): is waste of third priority concern, which is moderately toxic or which contains substances that are potentially highly harmful to human health or to the environment but are not persistent.
- Hazard Rating 4 (Low Hazard): is waste that often occurs in large quantities and which contains potentially harmful substances in concentrations that in most instances would represent only a limited threat to human health or to the environment
- Hazard Rating lower than 4: where the classification falls below Hazard Rating 1 to 4. The hazard posed by a waste can be considered to be low enough to allow the waste to be disposed of at a General Waste landfill with a leachate collection system.

The Hazard rating determines the class of landfill at which a waste is disposed:

H:H landfill – Hazard Rating 1 and 2
H:H or H:h landfill – Hazard Rating 3 and 4

The minimum requirements describe how to determine the Hazard Rating and how to use the Estimated Environmental Concentration (EEC) to determine the Hazard Rating or to delist a Hazardous Waste.

3.6.2 The South African Department of Water Affairs and Forestry: Minimum Requirements for Waste Disposal by Landfill.

This document addresses landfill classification, and the siting, investigation, design, operation and monitoring of landfill sites. In the landfill classification system, a landfill is classified in terms of waste class, size of operation, and potential for significant leachate generation, all of which influence the risk it poses to the environment. Graded requirements are then set for all aspects of landfilling, including public participation.

4 ENVIRONMENTAL BASELINE DESCRIPTIONS OF THE SITE

4.1 Biophysical

4.1.1 Topography

The morphology of the region is characterised by smoothly undulating terrain formed by inland dunes with altitudes ranging from 50 m to 100 m above mean sea level (asl). The study area itself forms a gentle slope of about 2%, which ends at the Rio Movene (Xingube River) in the west (characterised by ensized drainage lines). The altitudes of the area range from about 85 m asl in the east to about 60 m asl in the west. Approximately 1 km to the east of the site, there is a gentle ridge of elevation about 90 m above mean sea level that forms a watershed between the Rio Movene and the Rio Matola.

4.1.2 Geology (Source: Groundwater Consulting Services, September 2002)

Regional Geology

The region belongs geologically to the vast sedimentary basin that extends from Port Dunford (Natal - South Africa) to Quelimane (North Central Mozambique), and extends to the east as far as the Lebombo Mountains. The area is situated in the southern Meso-Cenozoic sedimentary basin, which is underlain by Karoo aged volcanic rocks. The top of these rocks consists of weathered volcanics. In the Maputo area, the position of the top of these volcanics is not well known, but expected to be more than 100 meters below the surface. The thickness and width of the sedimentary basin decrease towards the south, with the bottom of the basin in the Marracuene area reported to be as deep as 2 000m.

Site Specific geology

In terms of regional geology, the site is located on the eastern edge of the Movene Formation of the Lebombo Group. This formation represents a post Karoo volcanic

formation with a generally north-south strike. The formation consists mainly of acidic Rhyolites, although the Rhyolite may be accompanied by intercalations of less acidic rocks such as Andesite and Dacite, and even Basalt. The eastern edge of the formation consists of mainly basaltic rocks which can appear as dolerite dykes, and can also be accompanied by volcanic breccias. The reddish colour of the Rhyolite rocks is caused by dispersed iron oxide.

The whole formation dips in an easterly direction between 30° and 50°, and is overlain by a sedimentary formation of cretaceous deposits consisting of sands and clays. There is a clear geological contact running roughly north-south through the site, between the outcropping volcanic formation (Basalt/Rhyolite) on the west, and sedimentary formation on the east.

The presence of quartz and orthoclase in the Rhyolites prevents complete weathering to pure clays, and the residual soils are usually silty clays or occasionally sandy clays. The clay in the residual soils is mainly Kaolinitic, and the soils are therefore generally non-active. However, the frequent intercalations of basic (basalt), intermediate (andesite) and acid igneous rocks in the Lebombo Group can produce a range of soil conditions from active to non-active.

4.1.3 Soils

The site comprises predominantly moderately deep sands of the Infulane Formation in the southeast (Tertiary period), and hard rock lithologies in the form of Lebombo Rhyolites and possibly basalts, with intrusive dolerites in the northwest.

The soils vary greatly in depth, comprising of shallow silty sands in the topsoil of the "A" horizon with deep to very deep (5-15 m) stratified fine-grained silty sands. These silty sands are inter layered with clay lenses, and in places are red to dark red in colour. The clay contents very greatly, with moderately high contents within the upper layers associated with the valleys (Colluvial); with interbedded lenses of fine silt and clay in places at depth; and silty sands with very little clay occupying the dune ridges; and wind blown deposits.

On the basis of the auger hole and test pit soil profiles across the site, the soils are typical of weathered rhyolitic soils, ie. clayey silts and clayey sands in the transported soils, and sandy clays and silty clays in the residual soils.

Conclusion regarding soil suitability for the construction of the facility:

The site is underlain by predominantly clayey sandy soils of relatively low permeability, which renders the site suitable for the development of a waste disposal facility. The clayey sand is however not suitable for use in a compacted clay liner unless there is some bentonite addition. Alternatively a GCL should be used in lieu of compacted clay for the landfill liner.

In the areas of the landfill cells and the drainage ponds, the excavatable depths of the soils extend deeper than the planned depths of the cells and ponds, and no rock excavation is envisaged. With the exception of the western side of the site, where there is bedrock outcropping at surface, the excavatable depth of soil is in excess of 4 to 5m. There is therefore more than adequate quantities of cover material on the site for the long term operation of a landfill facility.

Across the remainder of the site, the soils are also sufficiently deep for the subsequent development of additional landfill cells and drainage ponds. There would therefore be ample soil available for use as daily cover material for the landfilling operation.

The clayey sand is slightly dispersive, and care must be taken to prevent erosion. Embankment and cut slopes must be topsoiled and vegetated as soon as practically possible.

The on-site soils would not be corrosive to buried concrete structures and elements.

4.1.4 Hydrology

The site has a gentle undulating topography with flat sections and gentle slopes (approximately 2,5%) to the north-west. Drainage on site is westwards towards the Rio Movene, which flows in a southerly direction approximately 500 m from the site. The Rio Movene is a seasonal river and is therefore dry for large periods of the year. The watershed between the Rio Movene and the Rio Malota is located approximately 1 km east of the site, resulting in a small catchment area above the site. There are therefore no distinctive drainage courses on the site, apart from some minor seasonal gulleys towards the southern and western sides of the site.

4.1.5 Geohydrology: (Source: Groundwater Consulting Services, August 2002)

The geohydrology of the area was investigated using a combination of geophysical and drilling techniques to determine the underlying characteristics of the area. In addition, a Hydrocensus of the area was also undertaken to determine the use of groundwater in the area.

The geohydrological Map of Mozambique (1:1000000) indicates that groundwater quality in the area is unfavourable for human consumption, the water being high in dissolved salts, imparting a brackish taste to the water quality.

It is known that most of the Tertiary sedimentary rocks (predominantly limestones and sandstones) were deposited in a saline environment, and although subsequent freshening of these waters occurs through groundwater flow and the process of leaching, they are still brackish. The geological processes that took place along the coast have been largely governed by sea level fluctuations caused by world wide climatic changes, and these conditions might have had an effect on many of the valleys in the south of the country.

Drilling

A total of eight (8) boreholes were drilled in the area, to determine the aquifers and the quality and quantity of the groundwater.

There are two distinct aquifers that have been identified. These include, a shallow or upper aquifer, generally associated with the young/recent sand deposits and colluvial materials, and a deeper aquifer associated with the fractured rock, or fractured rock aquifer. Groundwater in the general area is associated with the alluvial aquifer, the water levels being moderately shallow in most cases studied.

At the proposed site, there is evidence of a fractured rock aquifer associated with the Rhyolites, Basalts and younger intrusive bodies (dolerite).

Hydrocensus

The shallow alluvial aquifer is utilized by the local population throughout the area. The water is tapped from the sands either by shallow boreholes, or (in the majority of cases) from caisson or open hand dug type wells. The hydrocensus of the area indicated that there are no boreholes within a six-kilometre radius of the area, and therefore no utilization of the deep fractured rock aquifer within the immediate area. The closest spring is 2,8km to the southeast of the site, and is believed to be associated with the shallow alluvial aquifer. It is possible, that the water at the spring is being brought to surface by a rock barrier that is forming an underground dam. This has not been proven.

Water Quality

The water quality is moderate to poor, with the majority of the waters encountered being brak to the taste and mostly unsuitable for human consumption.

Borehole MHH8 has been drilled into a shallow fractured aquifer associated with the Rio Movene, and the water quality is moderately poor and brakish to the taste.

Seismology

In the preliminary geotechnical report (Design criteria for the Mavoco Hazardous Waste Facility No: MDD 0455-G-001, July 2002) it is stated that the proposed site is located in a seismic inactive area. The seismic risk of the site is not addressed in the geotechnical report compiled by Jarrod Ball & Associates.

According to Fernandez and Guzman (Ref 2), the area investigated is classified as having a seismic intensity of between V and VI on the Modified Mercalli scale (MMS) with a 90% probability of not being exceeded during a 100 year recurrence period.

An earthquake of VI on the MMS is described as follows:

- All people, in- and outdoors feel it;
- Windows, dishes and glassware are broken;
- Pictures and books fall of walls and shelves;
- Furniture is moved and overturned; and
- Weak plaster and poorly constructed masonry structures crack.

An earthquake with an intensity of VII on the MMS is described as having the following characteristics:

- Difficult to stand;
- Furniture broken;
- Damage to weak masonry;
- Small slides and caving-in along sand or gravel banks;
- Concrete irrigation ditches damaged.

The expected average ground acceleration values associated with these magnitudes of earthquake are indicated as:

- Horizontal acceleration: 66 to 126 cm/s^2
- Vertical acceleration: 45 to 83 cm/s^2

It should be noted that the seismic risk classification stated above is only regarded as an indication of the seismic risk of the site.

It is therefore recommended that a detailed seismic risk assessment of the site be conducted and if required, that the landfill cells and structures must be designed for such a hazard.

4.1.6 Climate (Source: Seed, October 2001)

The climatic description is based on data provided by the National Meteorological Institute (INAM), collected at the Umbeluzi Meteorological Station (Boane District).

The climate of Maputo province is tropical humid to sub-humid, with rainfall distributed along the year. The mean annual rainfall is 800 mm. The maximum rainfall corresponds to November and March and fifty percent of the annual rainfall corresponds to November, January and February. The lowest rainfall is observed between June and July, which contributed with only 2 % of the total rainfall.

AVERAGE MONTHLY RAINFALL

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	AVG
1991	182.2	95.7	91.4	6.6	9.9	36.3	18.6	0.0	13.6	6.0	67.2	97.9	52.1
1992	37.1	34.6	9.7	6.6	6.5	17.8	3.4	9.4	0.6	7.8	40.4	138.	26
1993	62.4	83.5	151.	35.7	29.0	9.2	17.1	12.0	1.5	25.7	32.8	4	59.7
1994	161.0	22.7	4	38.5	7.7	0.8	0.7	10.5	7.9	1-7.	36.6	92.4	46.6
1995	69.1	23.5	50.8	9.2	47.4	0.6	0.4	19.4	1.2	8	43.1	115.	40.6
1996	182.2	194.	45.9	44.7	44.5	0.2	14.0	5.7	0.5	85.3	47.2	1	63.6
1997	190.1	1	39.7	25.9	15.6	20.5	43.5	50.4	70.9	103.	75.7	142.	70.9
1998	261.0	62.6	100.	14.9	0.0	0.0	4.2	2.9	19.5	0	142.	1	65.4
1999	175.8	59.1	1	42.1	25.8	8.9	5.6	28.1	33.2	82.5	2	87.7	75.9
2000	108.5	230.	84.5	35.9	11.8	20.9	15.2	3.2	59.8	98.0	153.	113.	91.8

The mean annual temperature is 23 °C. The average annual temperatures vary between a minimum of 12 °C to a maximum of 24 °C, with extremes ranging from the minimum in July of 9.7 °C and a maximum of 36 °C in December/January.

The average monthly humidity values ranges from 60 - 75 %. These figures are subject to changes according to the season, the highest values being reported from January to March (app. 70 %) and the lowest in September (64 %).

The average annual, total evaporation is 125 mm and the highest values correspond to December (more than 250 mm). The mean monthly evaporation generally exceeds the mean monthly rainfall along the year, indicating that this is a water deficit area. For the period December through to February, precipitation exceeds evaporation.

AVERAGE MONTHLY EVAPORATION

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1991	132.5	95.7	109.0	106.2	82.4	81.8	120.0	129.5	137.8	147.0	150.4	116.6
1992	140.6	154.7	149.8	157.7	140.8	134.1	148.0	148.5	142.0	179.4	140.8	154.9
1993	150.3	108.2	83.7	104.3	105.5	107.4	106.3	134.7	121.3	98.3	117.3	155.0
1994	120.0	106.7	140.3	97.3	93.4	136.6	141.2	147.3	155.1	120.4	111.6	147.7
1995	171.5	131.6	133.7	138.0	100.6	123.9	145.5	134.9	130.8	156.6	116.0	112.5
1996	86.9	79.9	89.0	79.2	67.2	92.1	94.1	130.0	151.8	138.6	114.1	116.6
1997	92.1	106.2	90.7	98.1	106.7	110.1	98.9	101.8	95.3	103.2	105.6	96.3
1998	99.7	91.5	97.4	104.2	121.8	111.9	112.8	131.4	129.6	94.8	94.5	95.4
1999	92.0	68.7	79.9	68.8	94.4	98.6	108.5	116/6	155.3	88.7	106.8	94.0
2000	86.1	51.4	62.0	64.9	73.5	66.5	94.6	94.7	121.6	-	88.4	-

Eastern winds are dominant in the area, especially during the rainy season, but south winds are the strongest, with an average wind speed of 10 km/hr. The average wind speed varies seasonally, from 2 m/s in winter to 4 m/s in summer. Cyclone winds, typical of the rainy, warm season are seldom registered. Although cyclones and depressions generally originate in the Indian Ocean, most of them diverts before reaching the 30 °S. In the last 35 years only two cyclones reached the study area: Claude in 1965 and Demoina in 1984. The area had extreme rainfall during February 2000 that caused large scale flooding in the region.

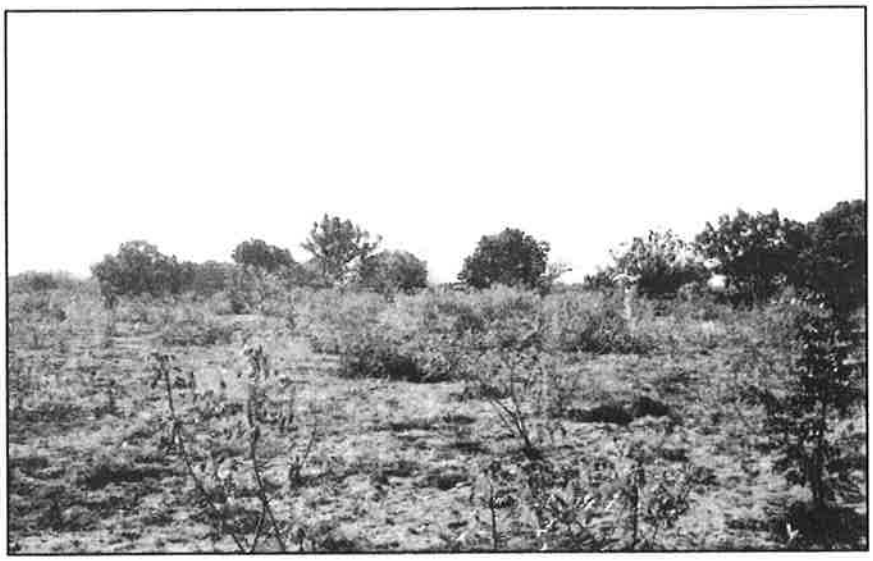
4.2 Biological

4.2.1 Vegetation (Source: Seed, October 2001)

Most of Maputo Province comprises a mixture of diverse vegetation types, collectively named the "Coastal Mosaic" (White, 1983), which include grasslands, woodlands, mangroves and dune forests.

The study area is characterized by secondary vegetation forming an open-woodland, with medium to low height trees, and herbaceous cover dominated by grasses. Originally, this area integrated an extensive area of tree/shrub savannah, ranging from the Limpopo River to the southern limits of Mozambique.

Ecologically the vegetation can be classified as climatic, where the plant communities are primarily dependent on atmospheric humidity, precipitation and air temperature. As a result of human pressure, the vegetation shows a biogenetic change in features, testified by a number of native and exotic fruit trees occurring scattered in the area. The predominant species are *Trichilia emetica, Sclerocarya birrea Annacardium senegalensis, Mangifera indica.* Edable fruit trees include *panduriforme, Strychnos madagascarienes, Dialium schlechter,i Annona senegalensis, Psidium guajava and Carica papaya.* Small scale farming of mostly of maize and cassava takes place in the area.

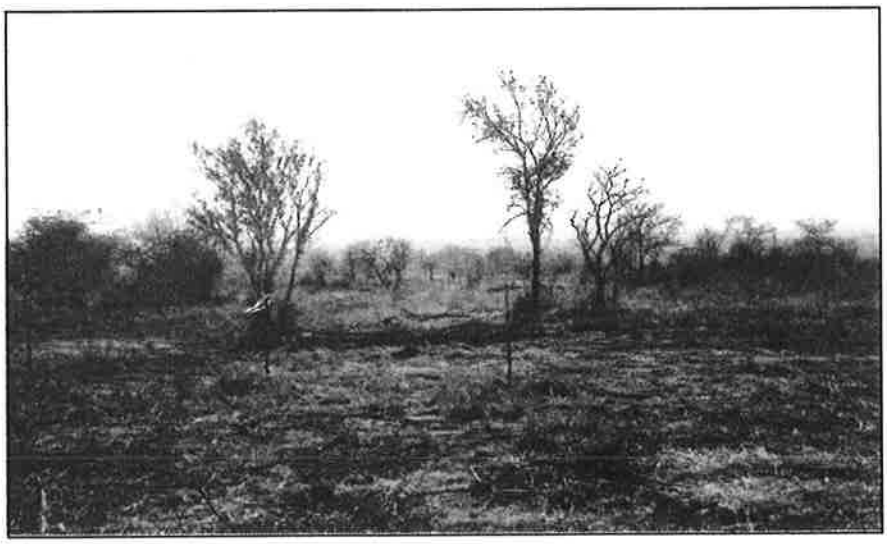


Site specific:

Although the land occupation by machambas and houses is low in the study area, the vegetation is typically secondary. However, the current conservation status of the vegetation may be regarded as reasonable, if compared to that of other neighboring areas, being possible to observe semi-closed woodlands in some small spots.

Land occupation by machambas is rather recent; information from the locals suggests that this is due to the war situation experienced in the area, which impaired agricultural activities, thus allowing the re-establishment of vegetation. A contrasting feature is the existence of an extensive trail network, opened by firewood collectors, which imposes a vulnerable condition to this woodland.

The site is situated within the coastal forest and thornveld vegetation group of the Savannah Biome. In almost 1/5 of the study area the dominant tree species is *Dichrostachys cenerea*, often mixed with *Acacia nigrescens*. Both species are used for firewood. The former produces good quality firewood and the latter are more used for coal. The grass cover is dominated by a mixture of *Eragrostis sp., Perotis patens* and a smaller *Rhynchelitrum repens* cover. Occasionally, in spaces with no wood cover, *Cynodon dactylon* forms up to 90 % of total plant cover.



Some indigenous fruit trees of rare occurrence in the region were observed, namely *Strychnos spinosa* and *Manilkara discolor. Anacardium occidentale* can be classified as very rare. The ornamental and medicinal species *Sansevieria sp.* is also scarcely found in the area.

The patches of *Sesbania sesban* observed may be an indication that areas where they were observed periodically accumulate water. Information given by the local population that use the plant resources from the area indicate that in some areas rain water accumulation results in small "pans" that remain for several weeks.

The herbaceous species *Agasenthemum boijerii, Baleria sp.* and the climber *Cissus rhivoilii* (mostly associated to *D. cenerea* and *A. nigrescens*) were observed.

A common feature to most of the areas is the occurrence of xerophytes species (e.g. *Acacia nigrescens, Aloe marlothii, Dichrostachys cenerea, Euphorbia ingens, Euphorbia spp, Hibiscus diversifolius, Euphorbia spp*). In relatively more deep soils some *Afzelia quanzensis* (pod mahogany) trees were also identified.

The Caster Oil plant (*R. communis*) and *Solanum panduriforme* occur occasionally. The former is found in the marginal areas of "machambas", where it is semi-cultivated for medicinal purposes (i.e. it is planted once and later reproduces spontaneously).

The latter is found associated with abandoned machambas, where the occurrence of *Momordica balsamina* (cacana) that grows spontaneously is also significant.

In relatively shallow soils 12-15 m high *Aloe marlothii* is found in grassland dominated by an association of *Themeda* and *Hyparrenia.* These species are the most important in the area close to the Southwest border of the study area. In this area, the change in soil type is evident. In the sub-plateau area in the South of Mozambique the vegetation with this characteristics is generally found in rocky outcrops with shallow soils that are rich in Iron and Magnesium. In such soils the wood cover is normally reduced (less than 10 - 20 %), due to firewood collection.

Floristically the vegetation is composed of a variety of native and exotic trees, scrub and shrub species, used by local communities for a number of purposes chiefly timber and

charcoal production, handcrafts, household firewood, food, livestock grazing and medicine.

In areas where the original grass has been replaced with small-scale farming, maize and cassava constitute the predominant crops. Beans and pumpkin can also be found.

The table below lists the main plant species than can be found in and around the area, in relatively reduced numbers and their uses.

SCIENTIFIC NAME	COMMON/COMMERCIAL NAME	MAIN USE
Acacia burkei	Micaia	Charcoal, Firewood
Acacia karroo	Munga	Charcoal, Firewood
Acacia tortilis	Sessane	Charcoal, Firewood
Combretum imberbe	Chivonzoane	Charcoal, firewood
Combretum molle	Monzo	Charcoal, firewood
Combretum apiculatum	Chivonzoane	Charcoal, firewood, medicinal
Acacia nigrescens		Charcoal, Firewood, robe
Hyparrhenia dissolute	Hlongue	Construction
Phragmitis australis	Hlanga/caniço	Construction
Rhynchelitrum repens		Construction
Themeda sp		Construction
Brachylaena discolor	Mbahla	Construction,
Terminalea sericea	Nconola	Construction, firewood, medicinal
Ricinus communis	Lhanfura	Cooking oil, soap, medicinal
Annona senegalensis	Romfa	Edible fruit
Dialium schlechteri	Enziva	Edible fruit
Manilkara discolor		Edible fruit
Salacia kraussi	Psincha	Edible fruit
Vangueria infausta	Mafilua	Edible fruit
Trichilia emetica	Kulhu	Edible fruit, domestic, cooking oil, soap

SCIENTIFIC NAME	COMMON/COMMERCIAL NAME	MAIN USE
Strychnos madagascariensis	Macuacua	Edible fruit, firewood
Strychnos spinosa	Massala	Edible fruit, firewood
Syzygium cordatum	Mulhu	Edible fruit, firewood
Garcinia livingstoney	Mbimbi	Edible fruit, medicinal
Dichrostachys cinerea	Ndzenga	Firewood
Xylotheca kraussiana	Chigutana	Firewood
Albizia adianthifolia	Gowane	Firewood, handcraft
Lannea schweinfurtia	Chiumbocanhe	Firewood, medicinal
Sacharum officinarum	Mova/cana de açucar	Food
Anacardium occidentale	Kadju	Food, Liquor
Momordica balsamina	Cacana	Food, medicinal
Panicum maximum	Chiundze	Forage
Psilotrichum africanum	Chigumatova	Forage
Albizia versicolor	Umpisso	Handcraft, charcoal, firewood
Dalbergia melanoxylon	Pau-preto	Handcraft, construction
Hyphaene coriacea	Munala	Handcraft, liquor
Helychrysum kraussii	Chiribjate	Hygienic paper
Artabotrys brachypetalus	Tinta	Liquor, local construction
Sclerocarya birrea	Canho	Liquor, edible fruit
Aloe marlothii		Medicinal
Euclea divinorum	Mulala	Medicinal
Euclea natalensis	Mulala	Medicinal
Hibiscus schinzii	Heta mbilu	Medicinal
Hibiscus surattensis	Coassa	Medicinal
Lonchocarpus capassa	Bandzo	Medicinal
Securidaca longipedunculata	Mulhalhovo	Medicinal
Sena petersiana		Medicinal
Solanum panduriforme	Ruluana	Medicinal
Ozoroa obovata	Chifuca	Medicinal,
Tabarnaemontana elegans	Kalhu	Medicinal, glue,
Dicerocaria senecioides	Hlehlua	Shampoo
Afzelia quanzensis	Chanfuta	Timber
Pterocarpus angolensis	Umbila	Timber
Melia azedarach	Siringa	Timber, medicinal
Eucalyptus sp.	Hlilamethi	Timber, poles, medicinal

4.2.2 **Fauna** (Source: Seed, October 2001)

Most of the fauna of the area is not restricted to the area and can be found in similar habitats in the region and its diversity is closely related to the soil types, the vegetation and on the use of those resources. Bird species, in particular, have a much wider distribution range, being most of the species shared with the other Southern African countries.

The fauna of the area is limited to small animals including insects, reptiles, birds and a reduced number of small mammals. Rodents are the most common mammals; the most abundant include the lesser cane rate (*Thryonomys gregorianus*) and the "house mouse"

(*Praomys natalensis*). The former species is typically found in cleared land, also occurring in areas of tall grass or reeds cover, reverine areas or small watercourses. The latter is probably the most common rodent species in Mozambique (Smithers & Tello, 1976), being tolerant to a wide variety of habitats (and equally adapted to "domestic" environment). They are both socio-economically important species due to the damages to crops by the former and to food stored in granaries by the latter.

Information provided by women from the communities, indicate that the lesser cane rate contributes significantly for losses in crop production. The guinea fowl (*Numida meleagris*) is also partly responsible for decreased crop production. During the war this species was hunted with traps, as a way of struggling against food scarcity, but this is no longer the case. According to the some women, reptiles are rarely seen in the "machambas".

The occurrence of the exotic urban rat (*Rattus rattus alexandrinus*) is to be expected; the species is well naturalized in the country and is commonly found associated with areas disturbed by road construction. This might be one of the species, which according to members of the local community is responsible for damages to food stocks in granaries. The Common duiker (*Sylvicapra grimmia*) used to be observed in the area with relative frequency. However, this species has been gradually diminishing.

A relatively detailed survey of bird species has been carried out in the EIA for the Mozal Power Line (Impacto, 1998) and the Motraco power sub-station, which is away south east of the site. The list compiled for the above mentioned study is presented below may probably be almost totally, extrapolated to the study area due to its proximity and ecological similarity with the Motraco Power station. Species of riverine and associated habitats, such as *Ardea cenerea* and *Egretta garzetta* occur in areas West of Beluluane, and in more densely vegetated areas *Francolinus natalensis* and *Circaetus fasciolatus* is to be expected.

Bird species identified in the Beluluane area

Scientific Name	**Common Name (English)**
Anhinga melanogaster	Darter
Anthreptes collaris	Collared sunbird
Ardea cinerea	Grey heron
Ardea melanocephalus	Blackheaded heron
Batis molitor	Chinspot Batis
Bubulcus ibis	Cattle egret
Chlorocichla flaviventris	Yellowbellied bulbul
Cisticola chiniana	Rattling cisticola
Coracias caudate	Lilacbreasted roller
Corvus alba	Pied crow
Dicrurus adsimilis	Forktailed drongo
Dicrurus ludwigii	Squaretailed drongo
Francolinus sephaena	Crested francolin
Halcyon chelicuti	Striped kingfisher
Halcyon senegalensis	Woodland kingfisher
Hirundo rustica	Europen swallow
Hirundo smithii	Wiretailed swallow
Lamprofornis nitens	Glossy starling
Nectarinia senegalensis	Whitebellied sunbird
Ortygospiza atricolis	Quail finch
Phalacocorax africanus	Reed cormorant

Phloceus intermedius	Lasser masked weaver
Phoeniculus purpureus	Redbilled woodhoopoe
Ploceus velatus	Masked weaver
Ploceus xanthopterus	Brownthroated weaver
Pycnonotus barbatus	Blackeyed bulbul
Scopus umbretta	Hammerkop
Serinus mozambicus	Yelloweyed canary
Sernus sulphuratus	Bully canary
Spermestes cucullatus	Bronze manikin
Streptopelia capicola	Cape turtle dove
Streptopelia senegalensis	Laughing dove
Tchagra senegala	Blackcrowned tchagra
Tockus leucomelas	Southern yellowbilled hornbill
Uraeginthus angolensis	Blue waxbill
Vidua macroura	Pintailed whydah
Vidua paradisaea	Paradise whydah

Source: Impacto. 1997. The Biological Diversity of Mozambique. A report prepared on behalf of the Ministry for Coordination of Environmental Affairs.

Domestic animals occurring in the area are mostly chickens and ducks and to a lesser extent (in isolated cases cattle) wild rabbits and pigs, can also be found. A few dogs and cats may also be kept as pets.

Site specific:

Based on on-site observations, it may be said that various bird species typical of riverine areas and associated habitats are found in the area. Analysing the distribution of bird species in South Mozambique (Parker, 1999), it has been possible to notice that a great number of them are shared with the remaining study areas, but not restricted to them. The remaining animal species are also not restricted to the area, being found in higher or lower abundance along the woodland that ranges from the Limpopo up to the South boundary of Mozambique.

The most abundant mammals are rodents, from which the lesser cane rate (*Tryonomis gregorianus*) and the "house mouse" (*Praomys natalensis*) are the most common.

Information obtained at the local level indicates that in areas with woodland cover snakes and rodents are fairly common, and the guinea fowl is sporadically seen.

The area is integrated in the distribution range of the common duiker, but is believed that this species is now locally extinct.

Some bats were observed near an area of dead trees at in the north-eastern section of the site, possibly the little freetailed bat, *Tadarida pumila*, a species widely distributed in Mozambique, that occurs very often associated with water courses.

Protected species/habitats

The existence of fauna is highly conditioned by the soil and vegetation types. In the past the area comprised a relative variety of small and medium mammals characteristic of rocky soils. The most important that can be mentioned are the Klipspringer (*Oreotragus oreotragus*) and in densely vegetated areas the red duiker- (*Cephalopus natalensis lebombo*, less common). The existence of common duiker (*Sylvicapra grimmia*) is also reported in the area.

4.3 The Socio-Economic Context of the Study Area

4.3.1 Regional overview of Boane District

The study area is located in the Southern Mozambican Province of Maputo, situated within the Administrative post of Matola Rio in the District of Boane. While much of Boane district can be characterised as rural a significant portion of the district borders the Cities of Matola and Maputo. Boane district is bordered to the South and West by Namaacha district and Matutuine district in the South; to the North of Boane is Moamba District, to the east of Boane lies the Cities of Matola and Maputo. Boane's total geographic area is 820 km².

4.3.1.1 Basic Population data for Boane

The total population of Boane is 56,703 according to the 1997 Census data, which makes up about 7% of the total population of the Maputo province. The table below outlines basic population data for the district of Boane.

Category	*Description*	*Number*	*%*
	Total Population	***56,703***	***100.0***
Rural/Urban Split	*Urban*	*17,222*	*30.4*
	Rural	*39,481*	*69.6*
Gender	*Male*	*26,697*	*47.1*
	Female	*30,006*	*52.9*
Administrative Divisions	*Admin Div of Boane*	*44,583*	*78.6*
	Admin Div of Matola Rio	*12,120*	*21.4*

* Source: Instituto Nacional de Estatistica, 1997

4.3.1.2 Administrative Divisions and Government Framework

Boane comprises two administrative sub-divisions, Boane Sede and the Administrative Post (AP) of Matola Rio. Each of these administrative divisions comprises respective localities or population centers (povoações). The district capital is Boane town located along the National Road No 2 (EN2) that serves as an international route to Swaziland and an alternative route to Moamba and South Africa.

The District Administration, which is responsible for public service administration in the district, comprises the following District Directorates of Agriculture and Rural Development, Health, Public Works, Education, and a district police commandant. The district administrator provides coordination and facilitation for these administrative bodies at district level.

4.3.1.3 Principal Economic Activity in Boane District

The principal activity of the majority of the population (1997 census data indicates that 69.6% of the population is characterized as rural), is smallholder agriculture. Aside from small holder agriculture there are some light industrial activities which are mainly situated closer to the Cities of Matola and Maputo including ceramics, block making and sand/rock quarries. Aside from this light industry, MOZAL, one of the most modern aluminium smelters in the world occupies a portion of the Matola Rio AP near the city of Matola.

4.3.2 The Administrative Post of Matola Rio

The Administrative Post of Matola Rio was created during the administrative reform process of 1986. It comprises seven population centres (povoações), which are illustrated in the table below. The AP Matola Rio is characterized by an overwhelmingly rural population whose primary activity and source of income is agricultural.

Despite its current profile as largely rural, the AP Matola has undergone a series of dramatic changes over the course of the past four years which include the construction of the Mozal plant and its supporting infrastructure, including roads and electricity supply to the area. Mozal has also contributed in various ways to the development of the Matola Rio AP with regard to health services, education, markets and other basic infrastructure improvements.

4.3.2.1 Transition to Industrial Development

The presence of Mozal has initiated a process of industrial development within the Matola Rio AP that has been sanctioned and promoted by the Government of Mozambique. One of the spin off initiatives of the Mozal development has been the development of the Beluluane Industrial Park (BIP) that was established by resolution No 15/99 of 2 October 1999 as part of an overall set of investment incentives developed by the Government of Mozambique.

4.3.2.2 Beluluane Industrial Park

The BIP has been designated a focal area for industrial development and has been granted special status as an Industrial Free Zone (IFZ), which will serve to attract industrial investment to the area. Its IFZ status means that IFZ operators are exempt from paying customs duties on the import of building materials, machines, equipment, accessories, spare parts and other goods destined for use in the licensed activity.

Customs exemptions are also granted on goods and merchandise imported for authorized project implementation and export activities. These exemptions are from VAT and the Tax on Specific Consumption (ICE), including domestic purchases (but excluding food, alcohol, tobacco, clothing and others).
The BIP development is officially sanctioned and zoned by the "Partial Plan for the Territorial Organization of the Administrative Post of Matola Rio," prepared in late 1997 and 1998 by the National Institute of Physical Planning of the Ministry of Plan and Finance, and approved by Resolution No. 1/2000 of the Government of Maputo Province.

Further discussion of the Partial Plan is presented in subsequent sections of this report.

4.3.2.3 Characteristics of Matola Rio AP

Although Mozal has brought a certain degree of improvement in infrastructures and social services to the area within its operational radius (defined as 10 km from the plant) overall industrial development, while one of the high profile features of the AP, is not its dominant characteristic. Despite the movement towards industrialization in this area, the vast majority of the Matola Rio AP is still largely undeveloped agricultural small-holder land that comprises populations which earn their livelihoods predominantly from agricultural production complemented by small scale non-agricultural activities such the commercialisation of natural resource products such as firewood and charcoal.

4.3.2.4 Population of Matola Rio

According to the 1997 census data, the population of Matola Rio AP is 12,120 of which 45.3% is male and the 54.7% is female. A detailed breakdown of population statistics by population centre is provided in the table below.

Population Centres of Matola Rio AP[1]

Population Centres	Population	Male	Female	No of Households
Mulotana	794	333	461	325
Beluluane	524	211	313	246
Djonasse	1,539	681	858	491
Djuba	823	368	455	331
Matola-Rio	2,650	1,231	1,419	637
Chinonanquila	5,790	2,664	3,126	1339
Mavoco	**393**	**187**	**206**	**125**

Figure 9 illustrates the administrative boarders of the Matola Rio PA and highlights villages within the AP and the district as a whole.

3500 families

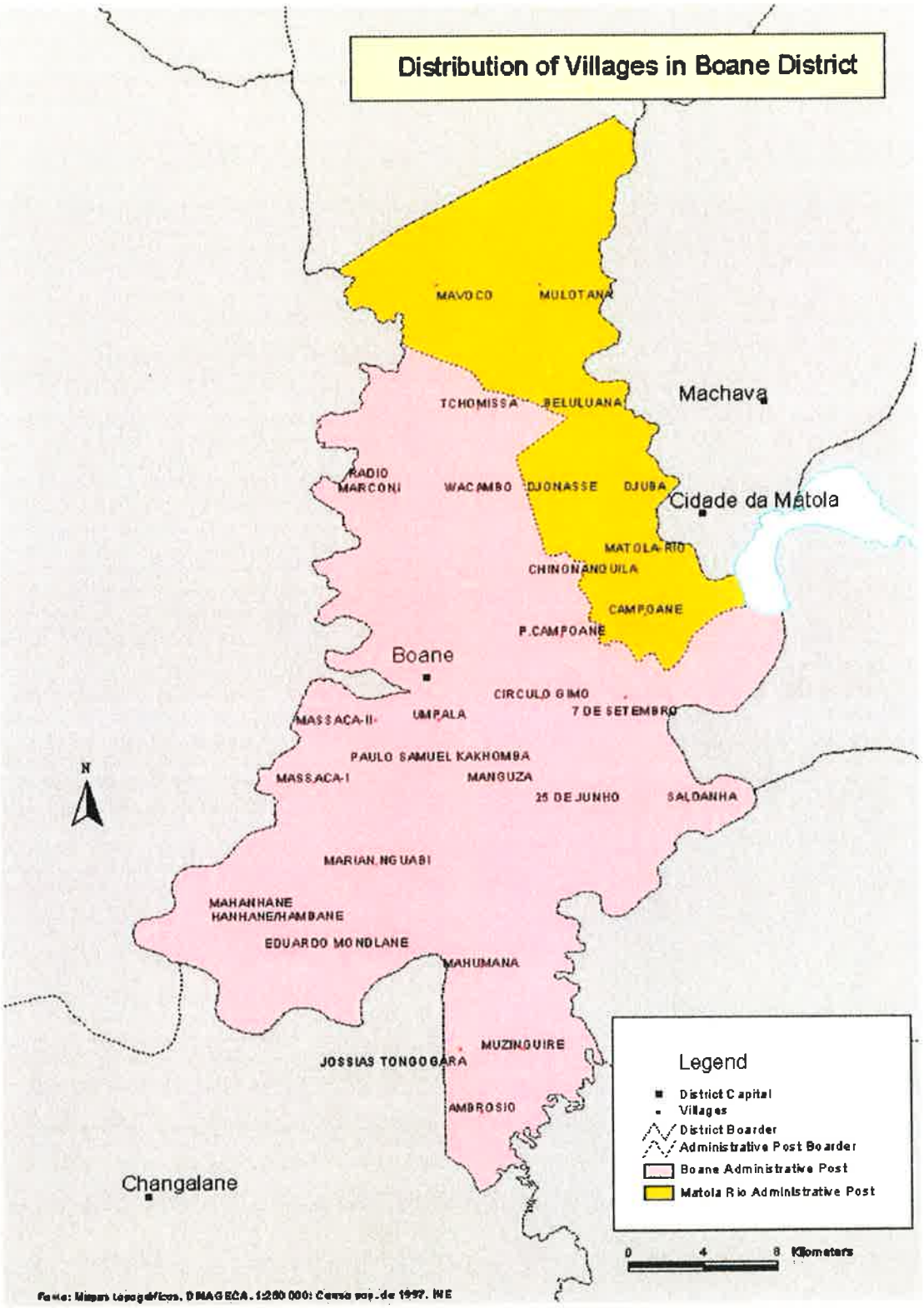
820 : 5 = 164 km² ~ 16400 ha

↓

46 ha / fam.

[1] The "povoações" included in this table is based on an interview with the Chefe de Posto for Matola Rio who stated that Mavoco was within her jurisdiction despite the official statistics indicating that it is part of the Boane administrative area.

Figure 9: Distribution of Villages in Boane District (Matola Rio AP in yellow)



4.3.2.5 Principal Non- Agricultural Activities in Matola Rio

Heavy industry
Mozal constitutes the only heavy industry in the area. The Mozal project is an ongoing endeavour with Phase 1 of construction and early operation established in early 2000 and rising to full production capacity in 2001. The Mozal aluminium smelter currently has the capacity for the production of 250,000 tons of aluminium per year. The construction of Phase 2 of Mozal, encompassing the provision of additional production capacity, is underway and will be completed by late 2003 early 2004. The additional capacity provided by Phase 2 of the construction will increase the overall capacity of Mozal to 500,000 tons of aluminium per year.

Light Industry
Light industrial activities which take place in the Matola Rio AP include a ceramics factory, block making for housing and commercial construction, salt production and sand mining for construction activities.

Service Industry
The service industry is made up of restaurants and nightclubs (or quintas), small shops, as well as guesthouses and small hotels for accommodation.

4.3.2.6 Markets

There are three official markets in the Matola Rio AP. One market in Matola Rio Sede along EN2, the Josina Machel Market in Chinonanquila, and the Rhulane Market in Djuba less than a kilometre from Mozal. These markets provide a variety of agricultural produce seasonally, as well as basic household items and value added agricultural products such as milled corn.
In addition to the official markets it is quite common to see agricultural produce and other goods for sale informally along the principal roads in the area.
Most of these light industrial and service organization are situated in the southern portion of the AP, along the EN2, which connects the cities of Matola and Boane. The northern and western portions of the AP are largely farmland used by smallholder farmers for household production. The majority of infrastructure development, new service-oriented concerns and housing occur toward the western portion of the AP, along the Mozal access road and between the road and the Matola River.

4.3.2.7 Social Services

The social service network that serves the Matola Rio AP can be described as inadequate to meet the needs of the population. The issues surrounding the social service network include the lack of material and financial resources and a low capacity of human resources in the institutions in order to address the health and education needs of the population.

Health
The network of health services can be described as week. Two health posts without internal capacity serves a population of over 12,000 in the PA. An additional health post is located in Campoane serves the population of Chinonanquila as well as other communities in the Boane administrative area.

The Beluluane health post has been rehabilitated through the Mozal Community Development Trust program and serves the population of Beluluane, Mulotana and Mavoco. The health post located in the Matola Rio area (directly across from the Administrative Post) that serves the area.

Both health posts provide primary health care and basic health services including pre and postnatal care as well as malaria testing and other primary health care services. There is no secondary health care in the AP, the nearest Health Centre is located in Matola City, which can provide secondary outpatient care but is unable to admit patients for more serious illnesses. The nearest hospital is Jose Macamo Hospital located on the road from Maputo City to Matola some 15 km from the Matola Rio AP administrative offices.

Education
Matola Rio AP has a total of eleven primary schools within its boarders. Primary schools in Mozambique have two basic classifications. Primary School 1 (EP 1) and Primary School 2 (EP2). EP1 covers grades 1 through 5, while EP2 covers grades 6 and 7. Of the eleven primary schools in the Matola Rio AP there are nine EP1s and just two EP2s. There is no Secondary School in Matola Rio and the nearest secondary school to the area would be either in Boane or Matola City.

4.3.2.8 Agricultural Activities in the Matola Rio AP

As mentioned above, agriculture within Matola Rio AP is primarily smallholder based, subsistence agriculture. There are little or no commercial agricultural activities and the vast majority of the population live of their household agricultural production. Principal crops identified in the area are: Maize, Cassava, Beans, Sweet Potato, Sesame, Groundnut and tomato.

The smallholder sector in Matola Rio, as in most parts of Mozambique relies on a relatively low level of formal agricultural inputs such as fertilizers and improved seeds and is based upon traditional agricultural methods. Agricultural production in the area, for most of the population, is subsistence level.

One particular problem in the area, partly due to the flooding of the year 2000, is accumulating enough seed stocks from one years harvest, in order to have enough for the next sowing season. Farmers struggle to find enough seed for the planting season. Figures on agricultural production are not available at the Administrative Post level.

4.3.2.9 Settlement Patterns

The settlement patterns in the Matola Rio AP can be described as dispersed and based on traditional rural agricultural settlement patterns. Outside of the villages (just seven population concentration points in Matola Rio AP), houses are few and dispersed and the households tend to be surrounded by their agricultural land (machambas).

It is clear that settlement and construction have greatly increased along the Mozal access road (from EN2 north to the Mozal plant) over the course of the past four years. Settlement usually takes place along the roads that are in good condition, with the traditional, more dispersed settlement patterns along the interior of the AP. Settlement is more intense on the western margin of the administrative post between the Matola River and the Mozal access road, the settlement patterns to the east of the road and north of Mozal adopting a more traditional smallholder agricultural pattern of dispersed housing circumscribed by farmland.

4.3.3 Description and Characterisation of the Study Area

The focus of the study area is based on the community of Mavoco in the Matola Rio AP, the area surrounding the proposed Mavoco hazardous waste facility as well as the area

encompassing the proposed access road alternatives. The boundaries of the study area were defined as the community of Mavoco and a 2 km radius around the proposed facility site and 2 km strips of land on either side of the proposed road alternatives.

4.3.3.1 Characterisation of Mavoco Community

The Mavoco community is situated approximately 4 km from the main access road to Mozal and Motraco, which essentially ends at the Motraco power substation. The principal access road for vehicles to Mavoco is currently the transmission line service road in the transmission line servitude) which local people have adopted as the quickest and easiest route to get to road transport links near Mozal. Mavoco lies approximately 11 km from the Mozal aluminium smelter, which can be seen from the house of the regulo or traditional chief.

Mavoco was established in the late 1950s (according to village elders) and was started by the son of the regulo at Mulotana who split form that community and founded Mavoco.

4.3.3.2 Mavoco's Population

The dominant ethnic group in the community is the MaRonga ethnic group and their principal language is Ronga. There are very few (if any) members of other ethnic groups living in Mavoco.

A typical family structure is extended and members of extended families are counted as members of the household. Household membership may be fluid rising and falling over the years based on extended family ties and obligations. The average household size for Boane district is 4.4 according to national census data from 1997, which would put Mavoco at more than one family member below average based on the figures in the table above.

The population of Mavoco consists of 125 households and a total of 393 people, according to 1997 Census data. Of the total population some 52.4% are women and 47.6% are men. Further demographic population data is not available at the community level.

4.3.3.3 Agricultural Activities

The population of Mavoco are subsistence smallholder farmers. Their principal crops were identified in a community meeting as being: Cassava, Maize, Peanuts Sweet Potato and butter beans, with limited tomato and sesame production.

The community indicated that they were unable to sell virtually any of the yearly crops as the agricultural production barely met their subsistence needs. Agricultural commercialisation for Mavoco amounts to little more than the sales of small quantities of agricultural produce, usually on the informal market.

Mavoco residents indicated that they were able to supplement their foods stocks and at time sell products like papaya, mango and other fruits, which they had harvested, from the local area or their machambas.

The availability of agricultural inputs such as fertiliser and improved seed varieties are beyond the means of the local farmers. They identified the poor rainfall as the number one constraint to their agricultural production. Community members remembered years past (colonial times) when the rains were good. There was a local cantina at which they

could sell some of their produce to buy things they needed but in recent years this extra source of income has disappeared.

"Mozal Machambas"
The people whose machambas have been relocated due to the Mozal project and their farms are known in the local community as Mozal Machambas. The perception gained from interviews with the community members indicated that the people on Mozal machambas are provided with support and training and a limited amount of these benefits was passed on to the farmers of Mavoco. It is clear that the opportunities gained by the inclusion of the Mavoco machambas in the relocation program, are currently seen as being separate from the community and are not necessarily designed to serve the Mavoco community as a whole. Specific examples mentioned include the use of the tractor for land clearing, access to seeds and technical training from the MCDT agricultural expert that works with the relocated farmers on their machambas.

Interviews with the representative of Codemo, Ltd., managing the agricultural program for the Mozal Community Development Trust (MCDT) indicated that a limited percentage of the Mavoco farmers had benefited from the MCDT program activities. As a rule MCDT support was confined to participants in the relocation program.

Livestock
There is no large-scale livestock farming within the Mavoco area. Local residents indicated that cattle farming were difficult due to a lack of funding for the acquisition of livestock and a lack of sufficiently suitable pasture in the area. Livestock found in the area includes goats and chickens.

The Codemo representative indicated that the MCDT agricultural program started a chicken production facility in the community to increase the capacity of the local communities to raise and maintain increasing numbers of chickens for household use. This program is in its infant stage.

4.3.3.4 Water and Energy Supply

Water Supply
The Mavoco community receives water from traditional sources in the area such as springs and traditional open topped wells. The water table in Mavoco does not provide a perennial water supply and during the dry seasons local residents are forced to get their water from the Movene River, approximately 5 km away. The water quality in the Mavoco area is good, but could be brackish at times.

Mavoco community members have identified water supply as one of their greatest concerns regarding the hazardous waste facility, indicating that the potable water in the area was already scarce and they fear losing the only source of potable water that they have. In the notes on the PPP for the site selection, the community requested a borehole if the project were to be implemented, to ensure a stable and secure water supply for the community.

The Codemo representative indicated that a well had recently been dug at the agricultural centre near Mavoco for use by the entire community. This well was not mentioned in the meetings and interviews held with community members previously.

Household Energy Supplies
The primary source for household energy in Mavoco for cooking is firewood collected from the local area. In terms of lighting the local population mentioned that they use a combination of firewood, paraffin, battery powered torches, kerosene and candles to

meet their lighting needs. These last three sources of lighting are only available in the markets (the nearest of which is some 11 kilometres away) and were often beyond the means of the local community members.

4.3.3.5 Social Services in Mavoco

Education
Mavoco has one Primary 1 (EP1 – grades 1 to five) school with approximately forty students. The school was recently rehabilitated and the community is not sure whether the MCDT or another organisation has undertaken the rehabilitation.

Students who want to continue their studies beyond EP1 are forced to leave the community for education in the Matola Rio area or in other areas where they have family members who could provide for them. Additional schooling for the community's children often represents a drain on the families' resources, which is beyond the means of most families.

Health Facilities
There are no formal health facilities to serve the Mavoco population and health care was raised by the community as a major concern. Most women giving birth in Mavoco do so at home and then visit the Health Post in Beluluane approximately 8 km away. The lack of formal health care is mitigated somewhat by the presence of local traditional healers but most community members indicated that they preferred to use the health post.

There are a few midwives within the community, for support during birth, but usually women went to the health centre once their babies are born, for postnatal care.

4.3.3.6 Non-Agricultural Income Generation

The two principal non-agricultural income generating activities for the local population are the production of charcoal from the local forest resources and the gathering and selling of firewood. Local residents get approximately 60,000 MZM (+/- USD 2.50) from a rice bag full of charcoal. A bundle of firewood can bring as much as 25,000 to 30,000 MZM although the price varies according to species and size of the firewood.

Other non-agricultural income sources include baskets and winnowing bowls both made from local natural resources.

The firewood and charcoal supply is currently in a relatively good condition but some charcoal makers currently walk up to 3km to get to the good sources for charcoal in the area.

Additional income is generated by the local population through the hunting of the local fauna such as the large bush rats that are abundant in the area. These animals are mostly used as an extra source of protein, but sometimes sold to other communities for extra income.

4.3.3.7 Land Use/Settlement Patterns (See figures 10-11)

? ha/family

The settlement patterns in the Mavoco area can be described as dispersed (farming based) settlement patterns. The population is concentrated around the centre of Mavoco and settlement within the 2 km zone of the access road are largely dispersed with households typically surrounded by their farming land.

The machambas in the area (except for the Mozal relocation machambas) are laid out in traditional fashion and according to traditional land rights. The machambas are typically decided by the Regulo and in the case of internal dispute the Community Council.

There are informal settlement and land use within the Motraco transmission line servitude. The machambas are extending up to the edge of the transmission line service road. At last least five or six households may be affected by the alignment of the proposed Alternative 1 for the access road, parallel to the transmission line. The number of machambas that would be affected by Alternative 1 is between 50 and 60 along the length of the access road. Further discussion of this follows in the section on socio-economic impacts.

Land acquisition for people wanting to settle in the area was easy but the increased pressure on prime farmland in the surrounding Mavoco area has led people to begin settling farther away form the Mavoco area. The future availability of prime farming land in the area is becoming increasingly difficult, due to encroachment of industrial development in the area.

4.3.3.8 Archaeological resources and Grave Sites

The elders of the community indicated that they were unaware of any graves that were located within the study areas. If graves are found during the construction phase, they are likely to be very old.

This does not eliminate the potential for graves or other archaeological resources located in the area. Mitigation measures will have to be proposed and implemented for any possible graves or archaeological finds on site during the construction of the facility and access route.

4.3.3.9 Non Governmental Organisation Activities

Both the Head of Matola Rio AP and the District Officials at Boane indicated that there were no NGOs working in the Mavoco area and the community members confirmed it.

Despite the fact that the community of Mavoco is just outside of Mozal's operational zone, the MCDT has been working in Mavoco to support the relocated farmers who have machambas in the area, allocated as part of the resettlement program. The MCDT has various programs in health, education and agriculture and was set up to support communities in Mozal's operational zone. Mozal's operational zone extends for a 10km radius around the smelter itself.

The MCDT is currently working in communities within this area in the health, education and agriculture sectors. Its focus is on supporting and reinforcing existing government structures in these areas. In Mavoco the MCDT is working in the field of agriculture, especially the resettled farmers who now have machambas in Mavoco. Its agricultural program provides support in four broad categories: land preparation, seed propagation, fertilisers and crop protection. In addition to these focal areas, a major component of the program is technical skills transfer for farmers within the resettlement program. The resettled farmers in both Beluluane and the Mavoco area have formed an association with the support of MCDT. The objective of the association is to provide the farmers in the area with a strong economic foundation for future sustainability once the support from MCDT stops. The agricultural support program in the area is scheduled to end in 2004 and it is unclear whether an extension of the MCDTs activities will be required.

4.3.4 Contextual Notes on the Mavoco Area

The following section highlights several contextual elements of the Mavoco community, which can be considered more "macro" issues that need to be taken into consideration when assessing the community of Mavoco and any potential impacts of the proposed facility on the community.

4.3.4.1 Mavoco as a Host Community for Resettled Farmers:

Mavoco has served as the host community for families that were relocated when the Mozal aluminium smelter was constructed. The community of Mavoco's ceded land, within its traditional control, to people from outside the community. Approximately 200 machambas have been demarcated and provided to community members from the area directly affected by the Mozal development.

The relocation site was not originally in the Resettlement Action Plan (RAP) developed for Mozal by the consulting firm ACER, International. The primary relocation site for farmland was located 4-5 km away, in Beluluane. When it became clear that additional land (approximately 200 farm plots) would be needed to relocate all of the families with machambas, affected by the Mozal development, the Government of Mozambique provided this land in Mavoco to the project.

Most of the people working the new machambas are from an area west of Mozal, on the other side of the Matola River called "Texlom" 15 km away. Many of the farmers experience difficulties with transport to ensure that their machambas are well and constantly tended. The location of the machambas creates a series of logistical difficulties for the farmers working on these plots.

The Codemo representative indicated that approximately 35% of the demarcated machambas in the Mavoco area had not been claimed. The remaining Mavoco machambas are being used as "overflow" locations for any additional farms that may have to be relocated with future expansions of Mozal.

4.3.4.2 Effects of Flooding

The Matola Rio area was heavily affected by the floods of the year 2000 and the people of Mavoco indicated that they were still attempting to replace tools and other household goods that were washed away in the floods. There were households in the community that had lost virtually everything in the flooding of 2000 and the community, as a whole, was still feeling the effects of the natural disaster.

4.3.4.3 Mavoco outside the Partial Plan for territorial organisation of Matola Rio AP

The community of Mavoco and the site for the hazardous waste facility is located outside the development plan for industrial development in the Matola Rio area. A landfill was planned but only as a domestic waste and non hazardous waste facility.

There is currently no planning document that covers the Mavoco area and the potential role of a facility of this kind to benefit future hazardous waste producing industries needs to be considered as a potential attraction for future industrial investment. As such it is crucial that existing plans be expanded or new plans be developed to monitor and regulate the future development of the area.

4.3.4.4 Effect of the War

The Boane district was greatly affected by the Civil war between Renamo and Frelimo. The district development Profiles published by the United Nations indicates that over 56% of the total population of Mozambique was displaced throughout the course of the war. Mavoco is no exception. Community leaders indicated that the area was not consistently habitable during the war and community members were limited to occasional visits to asses the damage caused by the war. The community members of Mavoco stayed in their community for brief periods of time and abandoned the area again when conflict arose.

4.3.4.5 Current Resettlement Issues

There are relevant issues related to the resettlement and compensation of local community members who were farming on the site proposed for the facility. In early July 2002 a team comprising representatives from the ministry of Agriculture at Central Provincial and District Levels, accompanied by representatives from MICOA conducted a study of the compensation requirements for the Mavoco area residents, who were utilising the site for the facility at the time.

Based on the study, which took place over four days, a list of 32 local residents who were entitled to receive compensation and resettlement benefits was established. Local residents were told, in the week of July 23rd to stop all activities in the area designated for the Mavoco hazardous waste facility.

Since then, none of the local population has received compensation or been allocated new land on which to restart their farming activities. This has created a significant amount of tension between the local authorities and the people of Mavoco and needs to be resolved as quickly as possible in order to ensure that the local residents do not become openly opposed to the project as a whole.

4.3.5 Conclusion and recommendations

Planned industrial development, is crucial to ensure that the needs of the local community are taken into consideration with continues development around Mavoco. These plans must guarantee that future industrial developments in the area will not compromise the community's ability to sustain their livelihood. Viable, acceptable and transparent alternatives should be found for the local population should further development require the relocation of the local population.

Given the current rate of industrial development and future plans for the area as an industrial investment zone, the addition of the hazardous waste disposal site can be seen as an incentive for industrial investment in the area. It is crucial that future development in the area be undertaken with the aid of strict zoning and urban planning guidelines that will allow the effective integration of the local population within the BIP and in the areas which are currently peripheral to the zone but which may in future be included, by design or by default, in the area.

5 EIA AND PUBLIC PARTICIPATION PROCESSES

5.1 Description of EIA process and Objectives

The activity is covered by the Mozambican Regulations on the process of Environmental Impact Assessment, Decree Nr 76/98 of 29 December 1998 issued by the Ministry for coordination of Environmental Affairs (MICOA).

The legislation requires that the Environmental Impact Assessment (EIA) procedure for the proposed development have to be followed. This entails a permitting process meeting various environmental reporting requirements. As a minimum a Terms of Reference is required for the project. This Terms of Reference must be approved by MICOA and followed by an Environmental Impact Assessment Report and an Environmental Management Plan (EMP) before construction commences. The findings of the EIA Report inherently form the foundation of the EMP - which will encompass the construction and operational aspect of the EIA process.

The EMP will contain the necessary mechanisms, guidelines and requirements (as identified by the EIA Report) to minimise the long-term detrimental effect of the development activity on the environment through the design, construction and operational phases of the development life cycle.

National and International regulatory standards for the disposal and transportation of Hazardous Waste such as the Basel Convention, ***Global Convention on the Control of Transboundary Movements of Hazardous Wastes***, March 1989 and the South African Department of Water Affairs and Forestry: ***Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste*** would also be incorporated into the requirements for the EIA and the EMP due to the fact that the Mozambican Authorities are still in the process of establishing guidelines in this respect.

Methodology to determine environmental impacts

1. Establish checklists for a.) Environmental characteristics and b.) Human development activities. These lists should be comprehensive and feature all the necessary items on which to base an informed decision.
2. The checklists are further categorised by single assessment sheets for each individual activity impacting on specific environmental parameters.

3. These are evaluated in terms of the following:
   - Nature and Extent
     Local impact (L), immediate (I), regional (R), and national (N).
   - Duration
     Transient (T), short-term (S), medium (M), long-term (L), permanent (P).
   - Status and intensity

Major, moderate and minor evaluated for positive as well as negative value weighting.

- Probability
  Improbable (I), probable (P), highly probable (H) and definite (D).

- Significance
  Low (L), medium (M), and high (H).

4. The matrix assessment provides a final evaluation of the potential impact of an activity on the full range of environmental parameters. The results are depicted either as weighted values, or as, coloured entities, representing:
   A - Insignificant low impact (not injurious to land and environment).
   B - Measurable impact (with proper planning and mitigation it is not injurious to land and environment).
   C - High impact on environment (but can be curbed by taking proper precautionary measures).
   D - Impact on environment, but considered positive.
   E - Impact that will be detrimental to environment.

5. Once the above assessment has been completed an objective evaluation of the potential impact of the activity can be assured. The activity impact is then offset against the list of environmental characteristics in the cause-effect interaction matrix.

5.2 Determination of environmental risk

The set of guidance documents entitled *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste* was commissioned by the South African Department of Water Affairs and Forestry (DWAF, 1998) with the intention to provide guidance on hazardous waste management practices, and to institute conservative guidelines to protect human health and the ecology against the uncontrolled handling and disposal of hazardous waste. The documents were designed to overestimate rather than underestimate risk, in the spirit of the precautionary principle. That is, where adequate information on risk is incomplete, it is advisable to assume worst-case conditions. In terms of risk assessment practices elsewhere in the world, the *Minimum Requirements* can be classified as a tier-1 approach. It is a screening tool to identify those situations that are obviously insignificant in terms of human health and environmental impacts, and to place focus on pertinent issues in the assessment. Tier-1 assessments accommodate large safety factors to compensate for limitations in the completeness of information and understanding of potential risks. Issues identified at this level, in accordance with the precautionary principle, allow a large margin of safety for protection of the environment and members of the community. In situations where the tier-1 approach leads to conditions of prohibitive costs, or where the situation around geology, hydrogeology and ecological parameters is well defined, the assessment can be refined in a tier-2 approach. The assessment can be conducted in a multi-tier approach, each subsequent tier leading to better clarification of the parameters that determine the level of risk that has to be managed. As these parameters become more certain, the need for large safety factors is reduced.

5.3 Public Participation Process

The Environmental Impact Assessment (EIA) procedure emphasizes the clear need for frequent interaction and communication between general public, parties affected directly by the proposed project, external interested and concerned organizations, as well as project scientists and engineers. Each aspect of the technical investigations generally includes a data collection and verification phase, followed by analysis and evaluation, then synthesis and conclusions. The findings of each phase are communicated as appropriate to external parties.

The project was advertised in the national media in Portuguese on the dates provided in the following table. Invitation letters and a BID document were distributed to I&APs as well as the community members to inform them about the proposed project and to invite them to raise their concerns at the public meetings. See Appendix G.

PUBLICATIONS/NEWSPAPERS				
PHASE	**DAYS**	**Notícias**	**Savana**	**Domingo**
Screening	23/08/02	♦	♦	
	24/08/02	♦		
	25/08/02			♦
	26/08/02	♦		
	27/08/02	♦		
Scoping	06/09/02	♦	♦	
	07/09/02	♦		
	08/09/02			♦
	09/09/02	♦		
	10/09/02	♦		
Draft Final	12/10/02	♦		
	13/10/02			♦
	14/10/02	♦		
	15/10/02	♦		

Four important public meetings took place in the course of the study. A summary of the main elements that came out of those meetings is presented below:

1st Meeting (Matola, August 28, 2002)/(Screening Phase of the EIA):

- The selected site falls under a village known as "Mavoco" and should be called as such and not Beluluane B as it was being called.
  - It was proposed that detailed studies should have been carried out in all 5 alternative sites to determine the best site, rather than identify one and then carry out detailed studies as was the case with the proposed facility site.
  - A site situated at 100 m asl would have been better than the current site which is at 60 m asl.
  - Interested and affected parties and the population at large had been poorly involved in the process up to this point (i.e. the 1st Public Meeting)
  - The 1st Meeting had concentrated on EIA aspects and the community wanted to know more about the engineering aspects of the project. This information would have provided the basis for people to concentrate on possible potential impacts.

Community Meeting (Mavoco, August 30, 2002)/(Screening Phase of the EIA)

- The affected community had the perception that the local authorities were not addressing their concerns. As a result their concerns regarding allocation of new plots for cultivation, resettlement and compensation for losses incurred in the area earmarked for the facility, were not being addressed adequately.

- There was a total lack of continuity between the timetable of the communities and those of the authorities and project developers. The community's interests were driven by the rainy season and the need to be prepared for cultivating the land in a few months, whereas the other entities had different priorities. The communities had the perception that little, if anything, was being done to guarantee that they would have the opportunity to cultivate new machambas in the forthcoming rainy season.

- There were differences in perception between the community, the authorities and the developers with regard to the extent of losses incurred at the site. The communities expressed losses that were considered too high by the authorities. However, as a demonstration of goodwill, the authorities committed themselves to provide, in all cases, compensation that would be substantially higher than the losses actually incurred.

2nd Meeting (Matola, September 11, 2002)/(Scoping Phase of the EIA):

- It was noted that there was land speculation in the Beluluane area. Disadvantaged families were selling their land to well-off people and as a result of this practice rich people, to the detriment of ordinary and poor families, were exclusively occupying the future industrial area. It was suggested that the authorities should intervene to keep social balance in land allocation and occupation.
- MOZAL hazardous waste seems to be clearly identified and classified but the same could not be said about the hazardous waste being produced by other domestic industries. The need to identify other sources of hazardous waste should be a priority.
- The potential construction of the Mavoco Hazardous Waste Facility for hazardous waste could be seen as a concrete incentive to establish a more transparent system of hazardous waste management and disposal in Mozambique.
- Actions and concrete measures should be taken to ensure that the waste landfill accommodates only hazardous waste produced inside Mozambique.
- Other components of the hazardous waste management system need to be fully examined before the facility becomes operational. Reference is made to components such as: transport, packaging and handling.
- The close proximity of facility to the Movene River demanded a thorough investigation to determine the possible impacts on water supply to Maputo and Matola.
- The current EIA needed to be conducted in association with other studies taking place in the same area.
- During the meeting a differentiation was made between the systems to manage hazardous waste and medical waste.
- The waste landfill would be open to inspection and audit by any interested and/or affected party provided that certain conditions were met.
- A contingency management plan, to deal with emergency and unforeseen circumstances was necessary.

3rd Meeting (Machava, October 16, 2002)/(Reporting Phase of the EIA):

- The need for the Mavoco Hazardous Waste Landfill Site to be constructed and operated following sound national and international environmental and social guidelines and standards was emphasized.
- The meeting highlighted the need for an area in the waste landfill that could deal with excess volumes of waste, not predicted by current estimations.
- The cost of services to be provided by the waste landfill facility need to be determined and made available to potential users urgently.
- The development of this project needs to be closely linked to the land use plan of the entire Beluluane Industrial Area. In order to avoid future social and human health problems it is crucial to establish, as soon as possible, the guidelines and principles to be observed in the allocation of land for housing and other human and social needs.
- Industrial and other potential users of the project's services need to be educated and encouraged to understand the benefits of disposing industrial hazardous waste in the facility. Old and current practices need to be abandoned as soon as the facility is made available.
- There is still an enormous amount of work to be done to establish the links between this project and the disposal of other hazardous wastes produced in the country. The definitions and classifications being used for the different types of hazardous waste are not quite consistent.
- The facility should be used at its full capacity in order to make sure that the investment made in a poor country like Mozambique, in terms of the construction and operation of the facility is worthwhile.

5.4 Socio-Economic Impact Assessment methodology

5.4.1 Overview of the Socio Economic Impact Assessment (SIA)

This study was conducted within the scope of the Environmental Impact Assessment for the establishment of a Hazardous Waste Facility in the Mavoco area of Boane District in Maputo Province.

The SIA has three primary objectives within the broader context of the EIA:

(i) to provide detailed background on the social and economic factors that make up the livelihoods of the local population living in the Mavoco area,
(ii) identify potential impacts both positive and negative of the proposed facility and access road in the construction and operational phases of the development.
(iii) to present mitigating measures to be undertaken in order to minimize the negative impacts of the hazardous waste facility as well as measures that may be taken to create positive synergies with the hazardous waste facility that may benefit the local population

This section of the EIA is divided into four distinct parts: background to the SIA, the SIA methodology, characterization of the study area, identified impacts and proposed mitigation measures. A list of individuals contacted and sources used in the conduct of the study is included with the general contacts and bibliography for the EIA as a whole.

5.4.2 Background to the Social Impact Assessment

While this study is part of the larger EIA there are certain elements of the overall project background that were considered in the development of the methodology of this study and are presented below for the consideration of the reader.

The Site Selection Process
The broad project area was previously selected as the most suitable site for the Hazardous Waste Facility by a previous consultancy (see, SEED 1999). The criteria for site selection and the public participation process executed to arrive at the decision about site location are detailed in SEED 1999.

Relationship to Mozal
The proximity of the area to the Mozal aluminium smelter has several implications for any study of the population living in Mavoco. It is important to bear in mind that the Mavoco community was directly affected by the development of the Mozal Aluminium Smelter, via the relocation of outside people onto farmland that was traditional under the control of the people of Mavoco. Due to the presence of affected parties in the Mavoco area, Mozal has an established relationship with community, which needs to be considered in the context of the SIA. The scope and nature of the relationship are broadly outlined in the Relocation Action Plan (RAP), however, it appears that the Mavoco area was never directly considered in the relocation action planning and that the relocated farmers in Mavoco were originally intended to be relocated at the Beluluane resettlement site. A discussion of Mavoco as a host community for relocated Machambas is presented in subsequent sections.

5.4.3 Study Methodology

This study was undertaken over the course of two calendar months and included the following methodological components.

Review of Secondary Literature: All relevant secondary literature for the conduct of the SIA was reviewed and evaluated. This includes documentation provided by MICOA, MOZAL and local authorities, including the relevant specialist studies completed in the context of the EIS for Phase 1 of the Mozal development.

Establishment of Interested and Affected Parties: An overall list of interested and affected parties was established within the context of the public participation process. In addition to the public meetings that made up a part of the Public Participation Process, individual meetings were held with various local and national government officials, a list of individual contacts during the scope of this work are provided in annex.

Establishment of the Project Impact Zone: After reviewing the secondary literature, the area of direct influence of the project (or the Project Impact Zone) was defined as approximately a two-kilometre radius around the site, while the Road Influence Zone was determined to be a two-kilometre path along either side of the access road.

Field Work: The fieldwork for this project included various visits to the project site and to the Mavoco area and included interviews with community members, and traditional and governmental authorities. The primary components of the fieldwork are listed below.

- **Semi structured interviews:** Due to the relatively low population density in the study area the development of household surveys was considered to be unnecessary, however information was gathered through a semi structured interview which were conducted were conducted with community leaders regarding various aspects for the socio-economic life of the community in the study area. The semi-structured interview guide is provided in an annex to this

report and will provide an idea of the types of information gathered during the fieldwork phase of the study.

- **Infrastructure Survey:** Along the access road alternatives 1 and 2 an inventory of infrastructures was taken in order to identify houses, grain stores and any their infrastructures that would fall within the servitude of a prospective access road alternative. These are represented graphically in Figures 10-11. In addition to the infrastructure survey, a preliminary assessment of the number of machambas and household that would be directly affected by the various proposed alignments of the access road alternatives.

- **Community Meetings:** As part of the PPP specific meetings were held with the community to discuss issues directly related to the Social Impact Assessment. One general meeting was held on the 28th of August and another with the Mavoco Community Council on the 4th of October. An additional community meeting will be scheduled to discuss the results of the EIA as a whole, once it is finalised

Public Participation Process: running in parallel to the SIA, the PPP provided fundamental feedback and points for consideration that were raised by the general population. Further details on this process are provided in the section of the Public Participation Process.

6 RISK DETERMINATION

As stated in the *Minimum Requirements for Waste Disposal by Landfill* (1998) the aim of the EIA is not only to "identify which aspects of the environment could be adversely affected by the development", but "to assist the designer in addressing any identified impacts by means of proper design". This section evaluates the geological, geohydrological and geotechnical information and the risk of air pollution in order to ensure that no critical factors or fatal flaws that could impact negatively on the environment, were overlooked.

6.1 Geotechnical (See Appendix C: Report 50827YH/G1, October 2002)

The assessment of the geotechnical impacts is based on the approach recommended in the Minimum Requirements. A walkover investigation of the site was conducted on 6 August 2002. This was followed by a desk study of the available information, including the geotechnical and draft hydro-geological investigation reports.

The following comments and recommendations have been made in the " Report on the Geotechnical Assessment of the Environmental Impacts for the proposed Mavoco Hazardous Waste Handling Facility, Beluluane, Mozambique, Report 50827YH/G1, October 2002":

6.1.1 Excavatability

Excavations will be performed at the site for construction founding of the structures, installation of pipes for water supply and sewage as well as for the landfill cells.

Rock outcrops and shallow refusal on bedrock was encountered on bedrock in the north-western part of the site. The landfill cells were subsequently moved eastwards to ensure that the excavations for the cells would be in soil material.

6.1.2 Undermined ground, quarries, utilities or filled areas

No indication of the presence of undermined ground, abandoned quarries or utilities or backfilled areas were found during the desk study or field inspection. No references to the presence of any of these features were found in the geotechnical investigation reports.

6.1.3 Instability of areas due to the presence of soluble rock

No indication of the presence of soluble rock formations was found during the desk study, field inspection or geotechnical reports.

6.1.4 Seismic activity

In the preliminary geotechnical report it is stated that the proposed site is located in a seismic inactive area. The seismic risk of the site is not addressed in the geotechnical report compiled by Jarrod Ball & Associates.

According to Fernandez and Guzman (Ref 2), the area investigated is classified as having a seismic intensity of between VI and VII on the Modified Mercalli scale (MMS) with a 90% probability of not being exceeded during a 100-year recurrence period.

An earthquake of VI on the MMS is described as follows:

- All people, in- and outdoors feel it;
- Windows, dishes and glassware are broken;
- Pictures and books fall of walls and shelves;
- Furniture is moved and overturned; and
- Weak plaster and poorly constructed masonry structures crack.

An earthquake with an intensity of VII on the MMS is described as having the following characteristics:

- Difficult to stand;
- Furniture broken;
- Damage to weak masonry;
- Small slides and caving-in along sand or gravel banks;
- Concrete irrigation ditches damaged.

The expected average ground acceleration values associated with these magnitudes of earthquake are indicated as:

- Horizontal acceleration: 66 to 126 cm/s^2
- Vertical acceleration: 45 to 83 cm/s^2

It should be noted that the seismic risk classification stated above is only regarded as an indication of the seismic risk of the site.

It is therefore recommended that a detailed seismic risk assessment of the site be conducted and if required, that the landfill cells and structures must be designed for such a hazard.

to be done

6.1.5 Impacts, Conclusions and Recommendations

The main objective of an EIA is to identify and evaluate potential adverse impacts of the project on the environment. From the geotechnical assessment it is concluded that the soil and rock conditions at the site may contribute to the following impacts:

- The sandy horizons encountered at the site may be prone to wind and water erosion, especially if the protective vegetation is removed.
- Breaching or damage to the berms or liners can result in pollution of the groundwater.

The conclusions and recommendations of the geotechnical assessment can be summarised as follows:

- The regional and site geology must be reviewed and a map must be produced indicating the site geology, dykes, faults, etc of the site.
- Neither the stiffness (at natural moisture conditions and during an increase in moisture content) or the collapse potential of the in situ soil profile was determined during the geotechnical investigations and could therefore not be assessed. This should be done.
- It is recommended that the expansive potential of the soil profiles be reassessed.
- The presence of ferricrete nodules encountered at shallow depth in some test pits is indicative of the presence of perched water table conditions during a wet season.
- It is recommended that a detailed seismic risk assessment of the site be conducted and if required, that the landfill cells and structures be designed for the expected seismic hazard at hand.

6.2 Geohydrological (See Appendix D: Report 50827CH/G1/2002, October 2002)

6.2.1 Introduction

The regional geohydrological setting is discussed in Senvano & Hunger's report where it is mentioned that the area is located on the volcanic sedimentary contact zone. The report further stated that the aquifer is not regarded as a usable aquifer except where extended fracture zones occur. The potential occurrence of perched water is also mentioned. The 1:1 000 000 scale geohydrological map of Mozambique outline the area as hosting brackish to saline groundwater resources. However, as stated in SEED's report the local communities are using water from hand dug wells or pounding water during the rainy season. No borehole water users were found during their hydrocensus.

6.2.2 Discussion

The following comprise the assessment of geohydrological considerations:

- The presence of evaporites such as calcrete and ferricrete indicate local fluctuating water levels from time to time. This must be considered and noted that a risk of localised saturation in the soils exist which could spread contamination in the unsaturated zone.
- The permeabilities calculated for the clays and transported sands do not comply for use as a H:H liner meaning the environment is not protected if spillage takes place outside the designed liner.
- The low permeabilities calculated for the clays and transported material in the test pits must not lead to over confidence in its capability to contain contamination. As result of the low permeabilities contamination can:
    - be washed away by run-off and flooding,
    - collect in the low permeable zone and leach out over a long period of time,
    - pond and slowly dissipate to spread with time.
- As result of the low permeabilities measured in the clays and transported sands, the monitoring of the drainage systems and run-off control must have highest priority. The river must be seen as the most vulnerable point that requires protection.
- The information on groundwater occurrence indicate pathways (no matter how slow) between the surface, the weathered zone and the fractured system and they are all vulnerable to contamination on surface.
- Abstraction from any borehole for production can only be done after groundwater modelling of the test pumping results shows that it will not impact on the site geohydrology. It will have to be monitored for water level and quality during the operating lifetime of the site.
- A monitoring programme should start as soon as possible to establish the impact of rainfall on groundwater quality, water levels and recharge. The suitability of the monitoring boreholes to detect contamination must be evaluated using tritium isotope as indicator.

6.2.3 Conclusion and Recommendations

It is concluded that the MAVOCO Waste Handling Facility has all the required geohydrological properties to be good a site for containing any contamination with minimal impact on the groundwater environment, provided:

- All the recommended information be gathered to confirm this statement.
- The management and monitoring of the site be conducted in the most responsible way according to the laid down guidelines.

- Any signs of contamination be handled and rectified immediately.

It is recommended that the following investigations be completed to fully understand and manage the MAVOCO site in such a way as not to impact on the environment:

- The drilling of three more boreholes to be completed in order to assess the geology, structural geology and geohydrology of the site.
- The modelling will need updating, incorporating all the new information.
- The final modelling will need review by a geohydrological modelling expert to confirm the validity of the model.
- The model will need to be verified with ongoing monitoring data.
- Electrical Conductivity profiles should be done to investigate stratification or leakage between aquifers in the boreholes.
- Baseline isotope analyses are recommended to establish recharge and groundwater residence time.
- A monitoring program based on the geohydrological data must be compiled, initiated and sustained.

6.3 Air Pollution Potential

6.3.1 Introduction

Environmental Management Services CC were appointed by AFRICON to assess the air quality impact from potential gaseous and particulate emissions that may emanate from the proposed Mavoco Hazardous Waste Landfill site in Maputo, Mozambique. The design capacity was given to be approximately 100 000 tonnes, with a fill rate of 5 000 tpa, i.e. a 20-year lifespan.

The main aim of the air quality impact study was to determine the potential for health, odour and dust impacts due to the Mavoco Hazardous Waste Landfill and to project suitable buffer and management zones for the site, if deemed necessary.

6.3.2 Methodological approach

The investigation included the impact of the disposal facility on the ambient air as well as the potential for a transportation accident.

Only a semi-quantitative transportation risk assessment could be done due to the lack of local accident statistics and an accurate definition of the toxicity of the waste. Statistical data from South Africa were used to develop spill frequencies.

In order to assess air impacts, an emissions inventory for the facility was compiled, atmospheric dispersion simulations undertaken, and predicted ambient air pollutant concentrations evaluated to determine odour, screening health and dust impacts. Four periods were assessed during the impact assessment, viz.:

- Emissions from one cell (filled as of 2007);
- Emissions from two cells (filled as of 2012);
- Emissions from three cells (filled as of 2017); and
- Emissions from four cells (filled as of 2022).

The dispersion simulations undertaken for particulate and gaseous emissions facilitated a *preliminary* health assessment of the impact of emissions, through the comparison of the simulated concentrations various health guidelines. Predicted concentrations of

odorants were compared with odour thresholds to determine the acceptability of potential emissions from the landfill.

6.3.3 Transportation Risk Assessment

Two route options from Motraco were included in the risk assessment. The predicted frequency of contaminating the air, water and soil pathways along the transportation route considered in this investigation was estimated and summarised in the table below:

Calculated spill frequency (per annum) for the transportation of waste along proposed route options from to disposal facility.

Pathway	Spillage and Truck on Fire		Spillage and No Fire	
	Option 1 [1]	Option 2 [2]	Option 1	Option 2
Air	2.12E-05	2.37E-05	1.06E-04	1.18E-04
Water	1.27E-04	1.42E-04	2.82E-04	3.15E-04
Soil	1.27E-04	1.42E-04	1.42E-05	1.58E-05

Notes: [1] – Straight route
[2] – Route bypassing residential areas

The evaporation (volatility) of spillage could not quantitatively be taken into account. Instead, it was assumed that when the truck is on fire, there would be 100% chance of air contamination and when there is no fire, there would be a 50% chance of the spill to become airborne. Furthermore, the probability of water and soil contamination was linked to the probability of rain and when a vehicle may be on fire (i.e. fire-fighting material such as water or foam), respectively.

The estimated likelihood of exposure was shown to be non-negligible (i.e. above 1E-6 per year). However since the waste at the time of the investigation, indicated mainly solid, metallurgical wastes, the significance of a spill may be confined to an area immediately to the accident. Furthermore, it is possible that the non-volatile nature of these wastes would not result in significant toxic gas clouds in the event of a fire.

Recommendation:
A final conclusion can only be based on the actual toxicity of the waste and it is therefore recommended that this risk assessment be extended once such information becomes available.

6.3.4 Odour impacts and odour management zone projection

Wind. ?

Hydrogen sulphide was used to illustrate the potential odour nuisance from the landfill. This substance was selected due to its common presence at disposal facilities. Although it may not represent the compound with the lowest odour threshold, without more accurate waste characterisation, remains a good indicator.

The predictions indicate that for the first 5 years, the odour impact would be confined to the landfill itself. Following the 4th cell, the predicted concentration for 10% odour recognition was predicted to extend to approximately 600m beyond the facility. Although no odour impact management zone was predicted based on the South African guideline for the operation of the first cell, a combined impact distance including all four cells, of 100 m was calculated. Taking into account the possibility of other odorous compounds, the 20% odour recognition value for hydrogen sulphide was used to define an odour management zone. ?

Recommendations:

- It is advisable to discourage any residential developments closer than 300m from the facility towards the north, northwest and western boundary;
- Similarly, residential areas towards the south should be discouraged for a distance not closer than 100m from the facility; and,
- The property boundary towards the east and southeast is adequately far removed from the disposal site without additional buffer zones.
- The odour impact management zones should be reviewed to quantify other odorous compounds and progress being made by the on-going site improvements.

6.3.5 Fugitive Dust Impacts

The predictions included the generation of airborne particulates due to vehicle activity (access road and on the landfill itself), tipping operations and wind erosion. Relatively low concentration levels were predicted. The maximum concentration levels were predicted to occur along the section running parallel to the landfill. This is due to the accumulation of emissions from the road surface and the activities at the disposal site.

Using the current South African daily average guideline concentration of 180 µg/m³ for PM10, the maximum daily average predicted fractions were about 54% for unpaved roads and 39% for paved roads. According to the UK guidelines these predictions fall within the "moderate" to "high" impact bands and exceed the target of 50µg/m³, recommended by the WHO. The latter concentration values were predicted to occur within 70 m from the landfill.
These predicted concentrations are relatively low when compared to typical hazardous landfill sites within South Africa; however, this is mainly due to the considerably lower disposal rates projected for the Belulúane site.

The dustfall levels were generally predicted to be "slight" with the paved road option. "Moderate" fallout levels were predicted with unpaved roads.

It is important to note that the impact from the roads only included the vehicle traffic projections for the waste disposal trucks. Additional particulate pollution would result with increased vehicle volumes expected to occur once the road is in operation. These projections are not known and can therefore not be accessed.

Recommendations:

- In anticipation of increased traffic volumes, it is suggested to select the treated road option.
- Dust from roads could be reduced by speed and traffic reduction, source improvement (e.g. tarring, gravelling or slag), and surface treatment (chemical stabilization).
- Dust from materials handling and bulldozing operations could be reduced by wet suppression and wind sheltering. Wind erosion could be reduced by wetting and minimizing the disturbance and frequency of disturbance of surfaces.

6.3.6 Gaseous Impacts

The predicted concentrations were all considerably less than the respective guidelines. So for instance, the predicted maximum daily average toluene concentration levels were less than 1% of the US Environmental Protection Agency's concentration reference concentration of 400 µg/m³, even after all four cells are filled.

Similarly, the incremental cancer risk values, using the US Environmental Protection Agency's inhalation unit risk factors, were predicted to be less than 1:10 000 000 (1-in-ten million) for dichloromethane and 2:10 000 000 (2-in-ten million) for benzene after four cells.

Recommendations:

- The predictions, using a number of key pollutants (benzene, dichloromethane, xylene, toluene), indicate insignificant health impacts. It is therefore not necessary to develop any community buffer zones based on health impacts. It is nevertheless recommended to initiate a regular (annual) monitoring campaign during which samples can be taken along the perimeter of the facility. This can be done at relatively low cost using vacuum canisters for later analysis in a laboratory.
- The range in the types and magnitudes of upsets that may occur at waste disposal facilities (e.g. ranging from cell wall leaks to cell wall failure, unauthorised waste being accepted, etc.) renders the development of 'worst-case' emission scenarios for such facilities complex. Despite the need for a conservative approach due to the potential, which exists for health impacts, the designation of a buffer zone based on possible impacts due to highly improbable events is difficult to justify.

7 ENGINEERING REVIEW OF DESIGN

7.1 Introduction

The review of the design of the Mavoco hazardous waste disposal facility was done by comparing it against the objectives of the South African *Minimum Requirements* as the baseline standard.

For the proposed facility the waste management and disposal process consists of a number of aspects such as waste sources, waste collection and transport to some degree, waste classification, waste treatment, disposal by landfilling and environmental control and monitoring. Each of these aspects was therefore viewed for compliance and whether the stated Minimum Requirement objectives have been met.

The waste management process of disposal does not only rely on the proposed design of the landfill facility for its success, but is also dependant on the operations and monitoring of impacts until many years after the closure of the landfill. The relevant field investigation reports and other documents were scrutinised. Relevant sections from the Minimum Requirements are highlighted and the design and operations are compared against the requirements

7.2 Discussion on Fatal flaws and overall suitability of the proposed site

No obvious situation presents itself to justify the existence of a fatally flawed site. However, based on the review of the Geotechnical and Geohydrological reports, the following issues are of concern that could impact on the design of the landfill facility:

7.2.1 50 Year flood line

Mention is made in the design that the site is located well away from the potential flood plane of the Rio Movene. Considering the flat nature of the region as well as the recent catastrophic floods in Mozambique, more precise information is required to confirm the position of the potential flood plane of the river. It is, however, understood that studies in this regard are underway.

7.2.2 Unstable areas

Reference is made in both the assessment of the Geotechnical and Geohydrological reports of seismic activity in the region. The geohydrological assessment of available information pointed towards the existence of a linear geological structure underlying the site.

Should the seismicivity and geology of the site present itself as real issues, a reassessment of the landfill design would be required.

7.2.3 Foundation conditions

Soil conditions could impact on the structural stability of the buildings on site as well as the landfill structure. Stated in the above assessment no mention is made in the geotechnical report of the expansiveness or collapse potential of the soil. The concern with the presence of such soils is how this would impact not only on the buildings, but also on the functioning and integrity of the drainage piping throughout the landfill facility.

With the potential for uneven settlements in the landfill due to potential collapse, breaching of the landfill liner specifically around drainage pipe protrusions could pose a substantial problem requiring specific attention.

The possibility of perched water being encountered during certain times of the year has also been highlighted in the above assessments. Where the presence of such perched water is found on site, a reassessment of the subsurface drainage system may be required. This is of specific importance as the combination of the soils as described above and the perched water could have negative effects on the design of services and foundations.

7.2.4 Overall suitability

The site conforms to virtually all the requirements regarding a high quality landfill site apart from the availability of low permeability soils. This is, however, not limiting as the engineering actions could mitigate the negative aspects. As highlighted in the relevant reports the in situ permeability of the soils on site is higher than would be required. The non uniformity in thickness of high quality cover material and liner soils has also led to careful engineering of the layout and the various facilities on site.

Overall the site is found to be suitable as the site offers a natural barrier against potential environmental impacts, is accessible, can be controlled and the drainage of uncontaminated and contaminated water is manageable.

7.3 Waste stream

The incoming waste into the Hazardous Waste Facility will come from two main sources namely:

- Hazardous waste from the Mozal Smelter with approximately 5000 tpa (ton per annum) and the
- Hazardous waste from Mozambique industries disposing approximately 2 200 tpa.

The proposed landfill facility will be developed as a H:H disposal facility with most of the waste emanating from Mozal. This is to be disposed in the landfill after pre-treatment. A significant part of the waste stream (almost 1/3) entering the hazardous waste disposal facility will not be treated and disposed in the landfill. This waste will be stored in a "transfer station", which, by definition, is an interface between the waste generating source and the final disposal facility.

According to the Minimum Requirements (basis for the design of the landfill disposal facility) any place at which more than 100 kg of a Hazardous Waste is stored for more than 90 days is termed a Waste Disposal Site and should thus conform to the standards for such facility. It also serves to note that according to the USEPA on Treatment, Storage and Disposal Facilities (TSDF), they rule that TSDF's may also serve as "transfer facilities" and may hold the waste that is appropriately packaged in accordance with DOT regulations for up to 10 days provided the TSDF is not the final destination for that waste. While allowance has been made in the design of the MAVOCO facility for the temporary storage of the unknown waste, this appears to be for an indefinite period. This procedure makes mitigation of the potential environmental impacts on a long term basis very difficult as the process remains open ended.

The owner of the facility will be faced with finding a solution for the disposal of difficult wastes by accepting the waste for storage at the landfill facility. If the generators of such

wastes were forced to find solutions for pre-treatment of difficult wastes prior to disposals it could ensure that no waste would be stockpiled for potential long periods. It could also spark some initiatives on the producers' side to look at more environmentally friendly products and give impetus to the "cradle-to-grave" principle of responsibility.

Although the information contained in the design criteria and waste facility operating plan gives a clear indication of the treatment and disposal method of the Mozal waste, no clear indication is given of the potential treatment of the known wastes from industries within Mozambique, other than temporary storage until an acceptable solution is found.

Reference is made in the reports of the potential for exporting the waste for further processing should the required process not be available or be to expensive. Concern is whether this should be promoted especially in light of the Basel Convention as referred to.

7.4 Disposal process

In the design it is assumed that most, if not all, the hazardous waste from Mozal and the hazardous waste from industries in Mozambique as per the inventory can be accommodated at the facility, following suitable treatment if necessary. The design further highlights the potential for a number of different pre-treatment methods for hazardous waste to render it suitable for landfill disposal be it physical treatment, chemical treatment, biological treatment, immobilisation, solidification, encapsulation, ash-blending or incineration. As stated, each treatment has significant costs associated with it, and thus would not warrant establishing a number of different treatment plants at the proposed hazardous waste facility. This is of specific importance in view of the uncertainties of the waste stream, and the small quantities expected initially.

While stating a number of pre-treatment options the design does not address the required potential additions or alterations required to the proposed facility in the event that a specific treatment process is required. This would be of importance to assess the versatility of the facility considering almost 30% of the expected waste requires treatment of some sort.

As indicated in the operation plan, the waste that can not be disposed in the landfill or accepted at the facility may not enter the waste disposal site. Hopefully this would encourage the generators of such wastes to find solutions for the disposal or treatment of their waste products before sending it to the landfill and thus not burden the owner with the onerous task of disposing of difficult unknown waste or be forced to stockpile the waste.

It is understood through communication with the design team that waste leach tests as well as lysimeter tests are being conducted on samples of the MOZAL waste. This is seen as a positive approach to improve on the confidence level of water balance modelling and thus potential generation and flow of leachate.

The proposed process of waste stabilization with cement or lime is supported as it is expected to reduce the mobility of the hazardous constituents within the waste and that it will make the waste easier to manage. The blending process as proposed using a loader on a flat surface is seen as a practical solution as long as the exposure of the operator and assistants to the process are well controlled and limited or minimized. This is highlighted and spelt out in the operating plan.

7.5 Proposed design

Access to the site is well controlled with facilities for monitoring of incoming and outgoing waste and vehicles. Waste will be analysed and classified in the laboratory provided in the administration facilities building for pre-treatment options. Options are available for temporary storage, blending within the facility or direct disposal in the landfill complying with environmentally acceptable standards.

Allowance has been made for the control and management of storm water (contaminated or uncontaminated) and leachate emanating from the facilities and operations.

In view of the uncertainties surrounding the final fate as well as the timescale involved, storage of the untreated unknown waste should be done in an absolute safe environment. The design states that no power will be provided to the temporary storage facility implying that no lighting will be available. This is emphasised on the cable layout drawing of the site. The opinion is expressed that it would not be possible to do proper monitoring of damaged containers or leakages or spills of the stored waste given the potentially dark wall finishing with no artificial lighting. Although "well ventilated", no mention is made in the design of the temperature conditions under which the various untreated products will be stored and how this relates to the envisaged waste streams.

The design does not elaborate or refer to standards applied in the design of the temporary waste storage or waste transfer facility. In view of the relevant and acceptable standards set for the disposal of waste by landfill, similar appropriate environmentally acceptable design standards need to be established for the waste transfer facility.

Apart from the temporary storage of waste in the transfer area, the guidelines as set out in the Minimum Requirements have been followed meticulously and that all aspects of a thorough design are represented in the MAVOCO hazardous waste disposal facility.

7.6 Proposed operating plan

The proposed operating plan is found to be comprehensive dealing with legal and management as well as health and safety requirements. The description of the site and surroundings along with a comprehensive description of the site facilities ring fences the required business area where a specific service is required. A comprehensive list of required resources to be provided by the operating contractors is also provided.

As stated the purpose of the Operational Manual, is to document procedures to be followed by staff, visitors, auditors, etc., carrying out specific key tasks within the confines of the hazardous landfill site. This allows for continuity of operational procedures and practices and in doing so minimises the risks in operating the landfill site and thereby protects the environment, employees, surrounding communities, etc. from hazards associated with this type of landfill. This document is also used to provide training of staff and ensures replication of operational practices, when there are changes in staff. This document describes the procedures for carrying out all the critical tasks on the site.

Facilities are to be provided for fire fighting and reference is made to fire fighting procedures. However, no reference is made to disaster recovery procedures in terms of environmental protection. In the event of an explosion or fire or probably a large spill, fire water may be used outside the landfill area allowing for large quantities of potential contaminated water to spread over a large area. Similarly large areas of soil could be contaminated during the disaster event. Procedures under such circumstances would be

required.

7.7 Discussion

The design and operations of the proposed facility are governed by a comprehensive list of legislation, agreements and design and management requirements. Substantial support therefore exists to develop an internationally and environmentally acceptable waste disposal facility.

Detailed assessments of the site and environment have been presented. Comprehensive design and operating plan reports and specification along with design drawing details of the facility have been presented to support the development of the waste disposal facility. This is found to represent a feasible and environmentally acceptable development.

A few issues described earlier such as

- the foundation conditions on the landfill site;
- the potential treatment of unknown wastes along with the flexibility of the proposed site to accommodate other treatment processes; and
- the set environmentally acceptable design standards for the temporary storage facility for unknown wastes need to be reviewed.

7.8 Conclusions

The design of the facility has taken the following into account:

- The local population and their physical environment, more specifically the water resources.
- Hydrogeology of the region.
- The geology of the region.
- Mitigation of the potential environmental impacts.
- Attaining and maintaining minimum waste management standards in Mozambique, so as to protect human health and the environment from possible harmful effects caused by the handling, treatment, storage and disposal of waste.
- Provision of a systematic and nationally uniform approach to the waste disposal process.
- Ensuring that Mozambican waste management practices are internationally acceptable.

Provided the operations are managed by a suitably qualified operating company, it could be found to be a practical and feasible solution to the disposal of the hazardous waste products.

7.8 Recommendation

Based on the available design reports, specifications and drawings of the proposed MAVOCO Landfill facility as presented by MOZAL, issues regarding the foundations, potential treatment options and temporary storage require further review prior to the final approval for the development of the hazardous waste disposal facility. to be done

8 DESCRIPTION OF ALTERNATIVES CONSIDERED

8.1 Facility (Source: Seed, 2001)

8.1.1 No-go Alternative

In Mozambique solid waste management is a growing environmental, socio-economic and public health problem. Municipalities face difficulties in the management of the increasing volume of waste produced by the industries and the population.

The growth in industrial production is increasing and the waste are indefinitely stored on the premises of the factories, dumped in a haphazard way at "dumping sites" that were not authorised by the municipalities or dumped together with domestic waste at municipal waste dumps. This situation poses a risk not only to the environment but also to the health of workers involved in waste handling, as well as to the general public.

The main solid waste disposal approach in Mozambique is the so-called "open dump" where waste categorization / grading is not carried out and industrial and medical waste are mixed with domestic waste in the same dumping area.

Maputo City, the Maputo District and the rest of Mozambique do not have adequate facilities for the disposal of municipal and industrial solid waste. With the development of the Mozal aluminium smelter and the consequent Beluluane Industrial Area (proposed to deal with 2nd order waste from Mozal), hazardous waste production in the province has increased dramatically. At present this hazardous waste from Mozal is stored in a temporary storage area on site, but this storage area will reach capacity in future.

Mozambique does not have a hazardous waste site and the nearest hazardous waste site is in South Africa. Transport cost from Mozambique to South Africa as well as the difficulty of transboundary transportation of hazardous waste under the Basel Convention, makes the disposal of hazardous waste difficult and costly. This situation could encourage illegal dumping of hazardous waste, which increase the risk of environmental and social disasters associated with hazardous waste happening.

The no-go option would therefore imply continuing with the status quo. This situation could have disastrous after effects that could lead to a long-term impact on the environment and the people of Mozambique.

8.1.2 Facility Alternative

Growing international awareness of the consequences of a lack of hazardous waste management plans, highlighted by the Basel Convention that Mozambique ratified, has increased the need for a national hazardous waste management program. MICOA identified activities related to obsolete pesticides management and other hazardous wastes as priorities to be included in their program.

As a result of the Basel Convention, DANIDA sent representatives to Mozambique, by the end of 1998, to investigate the hazardous waste production and disposal in that country and to propose a management solution. The evaluation team concluded that there was and urgent need to focus and put effort in the development of a strategy and operational procedure to manage hazardous and industrial waste. Among the major

activities and mega-projects, the establishment of a comprehensive hazardous waste management system was prioritised, since the delays in the coordination actions could result in major environmental impacts.

MICOA and consultants identified 5 areas to be evaluated for the potential development of a hazardous waste landfill site. The feasibility of developing the site at these predetermined positions was investigated. Each of the sites were assessed and ranked according to socio-economic, biophysical and public consultation criteria using a rating matrix. The Mavoco (Beluluane site 2B) site was recommended as the preferred site for the hazardous waste facility. This facility would be designed to accommodate and dispose of all the hazardous waste in Mozambique, until others have been established. All presently known waste streams would be treated and disposed at the facility, but the facility would also be designed to temporary store new waste streams until their treatment has been determined and dealt with accordingly.

8.1.3 Recommendation and Conclusion

The status quo "no-go" situation that currently occurs in Mozambique could result in major environmental damage over the long run. Cleaning this waste and rehabilitating the environment, transferring hazardous waste and treatment of the waste is becoming increasingly costly. Spillages and impacts associated with hazardous waste could only become known (without regular monitoring), years after it took place and by that time it could be toolate to prevent a major disaster. It is therefore recommended that the no-go alternative not be investigated further.

With proper planning and design of the facility to accommodate mitigation measures into environmental management of the facility, the environmental and social risk associated with hazardous waste could be limited. The existing situation for disposal of hazardous waste in Mozambique and the associated potential risk to human health and the environment could only improve with the development of a hazardous waste facility.

The alternatives selected and investigated for the proposed hazardous waste facility was done in a separate study that falls outside the scope of this investigation. This consortium accepts that the criteria used and the public participation conducted to determine the preferred site for the facility was adequate.

It is therefore recommended that a hazardous waste facility be built to mitigate the present no-go situation. This alternative will have the following benefits:

- **No more dumping of hazardous/industrial waste in unregistered dumping sites.**
- **No more disposal of hazardous waste together with domestic waste at municipal landfill sites.**
- **Decreasing storage of hazardous waste on properties that could spill and cause environmental damage.**
- **Controlled treatment of hazardous waste at a facility that has been designed for it, with proper monitoring in place to detect pollution at an early stage.**
- **Controlled transportation of hazardous waste to the facility.**
- **Decrease in environmental damage associated with disasters that could impact on human health.**
- **Emergency procedures in place to deal with spillages and leakages that could prevent or decrease the environmental impacts.**

8.2 Access Road

8.2.1 Introduction

A critical issue relating to the physical development of the Mavoco Hazardous Waste Facility and its operations, is the access to the site. A number of alternatives have been proposed for the access road to the Hazardous Waste Facility. These alternatives can be divided into surface alternatives and route alignment alternatives. These different alternatives will be discussed in detail in the following sections.

8.2.2 Surface alternatives for the proposed access road

Two alternatives for the pavement design have been proposed namely:

Alternative 1: Gravel road
The Access Road will have a width of 6 m with 150 mm wide unsurfaced shoulders on either side. The finished road shall be a minimum of 300mm above the natural ground level with side slopes of 1:2 and wide unlined trapezoidal side drains. The road will be surfaced with a 150mm Gravel Wearing course of at least G5 quality compacted to 98% Mod AASHTO density. Major impacts associated with this gravel road are dust and noise. This will have a limited health and social impact on communities living next to the road, especially with dust in populated areas covering crops.

Alternative 2: Emulsion stabilised sand road
The Access Road will have a surfaced width of 6 m with 150 mm wide unsurfaced shoulders on either side, constructed from the emulsion stabilised base material. The finished road shall be a minimum of 300mm above the natural ground level with side slopes of 1:2 and wide unlined trapezoidal side drains. The road base will be 150 mm Bitumen Emulsion stabilised sand of at least G6 quality, compacted to 98% Mod AASHTO density and the road will be surfaced by a Sand Seal. This alternative compared to a gravel road will have a positive impact socially. Dust will be kept to a minimum and noise will be limited.

8.2.3 Recommendation and Conclusion

It is recommended that alternative 2: Emulsion stabilised sand road be used for the access road. This will ensure improved vehicular safety and less noise with no dust. This alternative will have the following benefits:

- **Dust associated with gravel roads, that could influence the health of persons living next to the road will be limited.**
- **Dust associated with gravel roads, that could reduce crop production and/or influence the quality of the crops will be limited.**
- **Noise associated with gravel roads will be reduced.**
- **Road safety will increase for the safe transportation of waste, decreasing risk of spillages and environmental damage.**

8.3 Route alternatives for the proposed Access Road

8.3.1 Early Access Alternative

A number of alternatives for the route alignment have been proposed by Mozal / SLMR, MICOA and the consortium of consultants. Mozal / SLMR have expressed the possibility of establishing an early access route for the construction phase prior to the finalization and construction of the permanent access route. The first alternative proposed for the

permanent access road was to follow the Motraco transmission line, service road that connects the facility site with the Motraco yard. Motraco has a servitude, 50m on either side of the centreline of the powerline, and the early access road was proposed due to the fact that Motraco has not given permission for contractors to use this servitude as an access to the facility.

The following impacts are associated with the proposed early access road:

- The road begins just to the north of the Ressano Garcia Railway line and passes through Beluluane. The first several kilometres it follows existing tracks in a westerly direction through a heavily populated village with a mixture of households, businesses and public infrastructure such as primary schools and an agricultural centre. The first three kilometres of the proposed route would have a significant impact socially, due to the close proximity of dwellings and people using the road on a daily basis.
- In the fist half of the route the road cross underneath two overhead 400 kV transmission lines (One from Swaziland and one EDM line for Mozambican electricity provision). Construction activities could impact on these lines and disrupt electricity provision.
- The route transects cultivated fields by associations of farmers, making it difficult to negotiate and receive agreement on compensation.
- The route will turn north in an area of "Machambas" and transect farms.
- The route will cross the 400 kV Motraco transmission line twice, with potential impacts on service provision.
- The route is not an existing road throughout; it is a track for 30-40% of the route.

Recommendation and Conclusion

Although the proposed road is an existing one, it would require improvements and widening in certain areas which, at least in the first three kilometres of the proposed road would entail a significant disruption to current activities including households as well as safety concerns regarding the primary school. Along the length of the road compensation would be required for farmland lost and any trees that would need to be removed along the current verges of the existing roads side.

It is proposed that the early access road not be considered as an alternative and that the alignment chosen for the permanent access route also be utilized for the early construction access route. By following the same alignment, potential environmental and social impacts are minimized and concentrated along a single axis rather than distributed and duplicated.

8.3.2 Key principles for the selection and assessment of the alternatives

The choice of alignment for the proposed access road is complicated from a direct social and environmental impact perspective due to the influence it may have on communities settled in the immediate location of the facility site and access routes. The key principles, which influence the identification and selection of alternatives, are the following:

- Limiting the influence of the proposed alignment on existing communities as little as possible; which includes the disturbance to "machambas" or plots, homesteads and cultural features (such as graves).
- Limiting the potential resettlement of people who have already been through such a process to a minimum.
- Keeping construction and vehicular traffic away from areas, which have schools and churches, and areas with a high population usage density.

- Risk of contact and exposure of waste through the transportation of waste.
- Critical environmental components such as wetland areas and river crossings.
- Traffic safety associated with the transportation of hazardous waste.
- The shortest distance possible for the transportation of hazardous waste to minimise environmental damage as a result of spillages and accidents.

8.3.3 Alternative Route Alignments (See figures 2-8 - layout maps for the alternative routes)

Three preliminary alternatives were identified. It can be accepted that all the alternatives selected will impact on a section of the local community. The potential social impacts will have to be limited as far as possible. The three alternatives identified are:

Alternative 1:
This alternative follows the existing N4 Maputo road to the access road of the Mozal smelter. The road to Mozal and the Motraco yard is an existing asphalt road. From there a new section would have to be built in a line parallel but directly south of the overhead electrical lines from the Motraco yard to the Mavoco Hazardous waste site. The road will be aligned outside the servitude for the electrical lines.

Approximately six kilometres in length, this access road alternative would follow the servitude for the existing transmission line on the south side. This alternative would pass directly through the Mozal machamba resettlement area adjacent to the Mavoco Community and would entail both compensation and in some cases a second resettlement of those people working machambas within the projected road servitude. The road design calls for a seven-meter wide road with a servitude of approximately eleven meters on either side. This would in turn require the disruption of approximately 50 to 60 machambas that are situated along the current transmission servitude. Approximately 70% of these machambas belong to people who have previously been resettled within the context of the Mozal project.

In addition to compensation requirements for the lost farming land and the required second resettlement of some of the farming population along the road, it is estimated that approximately four to seven households would be affected by the proposed alignment of this alternative and these household members would require resettlement and compensation for loss of housing as well as farmland.

Alternative 2:
This alternative follows the same route as described in alternative 1, with the exception of two diversions to avoid a difficult, low lying marshy area and the machambas that make up the Mavoco resettlement area. After the Mavoco resettlement area the route alignment would follow parallel to the transmission line servitude up to the proposed location of the project.

The area adjacent to the southern edge of the Mavoco resettlement machambas has been settled with households and care will have to be taken with the final alignment of the road to avoid as many of these as possible. It is estimated that this option would involve the disruption of 25-35 informal machambas and between 4 and 10 households depending on road alignment. However with this alternative the advantage is that people affected by the resettlement in the Mozal Resettlement scheme would not be impacted upon.

Alternative 3:

A suggestion was made by MICOA to investigate a third access alternative. This alternative follows the existing asphalt road between Moamba and Boane (EN2) for approximately 33 km. A new access road will have to be built from the EN2 to the facility, which crosses the Movene (Xingube) River or deviates around the river to the proposed facility.
Land use and settlement along the EN2 from Matola Rio to Boane is characterized by intermittent dense population and mixed land use patterns (housing, light industry, agricultural production/research) and crosses the Umbeluzi River at several points. Between the city of Matola and Boane, the EN2 experience heavy traffic volumes due to its international connection with the Swaziland border post in Namaacha. After the intersection for Namaacha, the traffic levels drop significantly and settlement patterns adopt a more dispersed and rural character.

The additional work required to access the proposed hazardous waste site would include improving a stretch of existing road approximately 2.5 km long from the EN2 to the entrance to the Mavoco Hazardous Waste Facility. The improvements would require a bridge span over the river Movene, which although passable in the dry season with a 4x4 vehicle, would require a bridge for perennial access to the site. This particular section of the existing road (at approximately km 1.8) is extremely low laying and would be prone to flooding in heavy rain conditions.

Conclusion and recommendation:

The alternative 2, route alignment is an attempt to mitigate the most significant social impacts associated with alternative 1 and is the preferred alternative between alternative 1 and 2.

Considering alternative 3, although the land on either side of the existing road from the EN2 contains no housing, additional research would be required to determine the level of compensation required for the loss of arable land to farmers in the area. Aside from compensation issues related with this options further questions need to be raised in relationship to the transport of the hazardous waste along the EN2, particularly in the high traffic volume section of the road. Another key question to consider is the effect of the extension of the transportation route by an additional 15 to 20 km from the Matola Rio Bridge. The extension of this route and costs associated with the future transport of the waste via this access route may present companies with additional transport costs that they may be ill prepared to accept. This could result in reluctance by local Mozambican firms to use this site in future to dispose of their hazardous waste.

The consideration of this potential alternative 3 requires further study in order to properly assess the costs and benefits involved with the choice of this alternative and its impact on the future use of the facility by local industry.

8.3.4 Comparative assessment of the proposed alternatives

The following table is a comparative analysis between the three proposed alternatives of potential impacts associated with these routes.

ALTERNATIVE 1: Following the Motraco electricity lines from Motraco to the facility in a parallel line outside the servitude.	**ALTERNATIVE 2: The same as alternative 1 with two deviations to avoid "machambas" and a marshy area.**	**ALTERNATIVE 3: Following the existing Moamba - Boane road (EN2) with an existing road from the EN2 to the facility.**
Relocation of 50-60 formal Mavoco resettlement machambas a 2nd time. Compensation for 2nd relocation and crops in the field costly.	Relocation of 25-35 informal machambas. Compensation for crops in the field.	This route goes through the heavily populated city of Boane.
Resettlement of 4-7 households with compensation for loss of housing and farmland	Resettlement of 4-10 households with compensation for loss of housing and farmland	No households will be impacted on the existing road from the EN2 to the facility.
A marshy area next to the transmission line will be crossed, making construction difficult and costly.	The route will deviate around the marshy area, resulting in less costly construction of the road.	A bridge will have to be constructed across the Movene River on the existing 2,5 km from the EN2 to the facility.
The road construction near the Motraco line could impact on cable stays of the pylons – disrupting electricity supply.	The road construction near the Motraco line could impact on cable stays of the pylons – disrupting electricity supply.	This road crosses rivers that are used for potable water and irrigation purposes. There is an increased environmental risk of spillages.
The route is approximately 6 km long from the Motraco yard to the facility.	The route is approximately 7 km long from the Motraco yard to the facility.	Increased travel time and distance (40km from Mozal) will increase risk of exposure and potential spillage and disasters.
The Motraco oil sump will have to be relocated.	The Motraco oil sump will have to be relocated.	The entire route will require increased erosion protection and stormwater management to diminish pollution effects next to the road.
The route is straight and poses minimum risk in terms of road safety for transportation vehicles.	This route has a technical risk associated with the 2-4 turns in the road to deviate around the marshy area and machambas. Proper design would be needed to ensure road safety for transportation vehicles.	Sections of the EN2 road will have to be rehabilitated to increase road safety for large vehicles transporting hazardous waste (shoulders, barriers, cat eyes etc.)

8.3.5 Strategic Evaluation Principles

Strategic issues associated with all three alternatives are the following:

- The old Boane highway was upgraded from gravel to asphalt with the construction of Mozal. This resulted in an immediate demand for land next to the road. No provision was made to plan new development patterns. The road was not designed to handle the amount of traffic associated with the new development in the area and the existing road reserve is not wide enough to make the road a two-lane route. If the road must be upgraded to two lanes in the future, property owners will have to be relocated or compensated for the extra land needed.
- The establishment of a formal road to Mavoco could result in the same development pattern along the access route, without planning and proper design of the road to deal with the increased amount of traffic.
- Considering alternatives 1& 2, the social impact is certain and must be mitigated to impact on as few people as possible with regard to relocation.
- Alternative 1 & 2 could result in increased access to the area and through fare to the Moamba - Boane road.
- The distance for the transportation of hazardous waste increase dramatically in alternative 3. This will result in increased exposure risk associated with spillages, accidents and major disasters, which could potentially occur on the road. There are sections of the Moamba – Boane road that would need extensive rehabilitation to ensure that road safety standards associated with the transportation of hazardous waste is met, reducing possible accidents and risk of spillages.

8.3.6 Summary assessment of the route alignment alternatives

Summarizing the opportunities and constraints of the above categories the alternatives can be grouped into two. Alternative 1 and 2 can be grouped into one, named the Motraco Route access alternative with alternative 2 as the mitigation for alternative 1.

Motraco Route Access Alternative:

- The strategic considerations for this alternative will be predominantly social in nature. The social cost of resettlement and compensation of people currently living on, and utilizing the land and environmental resource base have to be objectively compared to the Moamba - Boane Road alternative.

Moamba – Boane Road Access Alternative:

- The Moamba – Boane Road alternative has a significantly less direct social cost implication. This route is however much longer in distance from Mozal and the surrounding future industrial area and the exposure risk to communities living adjacent to the route could have a major impact.
- Prolonged exposure increase the risk for accidents and catastrophes in terms of road user safety and potential environmental disasters. Spills or pollution of sensitive environmental features, such as river and stream crossings en route could impact on potable water in the area.
- This route has an increased transportation cost from the mayor sources of Hazardous waste such as the city of Maputo and the Mozal aluminium smelter.

Final comparison summary:

ASPECT	MOTRACO ALTERNATIVE	Time period	MOAMBA - BOANE (EN2) ALTERNATIVE	Time period
Social cost – relocation of machambas	25-35 informal machambas = medium impact	Short term	Informal machambas / loss of arable land = low impact	Short term
Compensation for houses & machambas	4-10 houses and informal machambas = high impact	Medium term	No houses = no impact	Short term
Loss of crops and cleared machambas.	Medium impact	Medium term	Loss of arable land – no crops at present = low impact	Short term
Loss of income	High impact	Short term	No impact	Short term
Loss of resources	Wood and charcoal = High impact	Medium term	Wood and charcoal = High impact	Medium term
Transportation cost regarding length of road	± 6km from the Motraco yard = low impact	Long term	± 40 km from Mozal = high impact	Long term
Environmental risk	Minimum risk of spillage = low impact	Long term	Longer route – risk of spillage = high impact	Long term
Pollution of ground / potable water	Minimum risk = Low impact	Long term	Increased risk associated with route length = high impact	Long term
Pollution of crops – reducing quality	Short route = low impact	Long term	Long route = high impact	Long term

8.4 Conclusion and recommendations

The Moamba – Boane route alternative has less social cost associated with the route, but much higher impacts relating to transportation cost and the potential for spillage and major environmental disasters.

The Motraco route alternative does have social implications relating to relocation and compensation for machambas in terms of loss in income, relocation cost as well as loss of prepared machambas. Mitigation measures to deviate around formal machambas, that have already been relocated during the implementation of the Mozal project and around a low laying marshy area, ensures that the social cost associated with relocation is not of high significance.

It is clear that the social cost associated with the Motraco route alternative is outweighed against the environmental risk and escalating transportation cost of the Moamba-Boane road. It is therefore recommended that Alternative 2 following the Motraco transmission line with two deviations is the preferred alternative for the proposed access road. Alternative 3 should be investigated in much more detail if this option is to be considered in the future.

9 IMPACT EVALUATION AND MITIGATION – HAZARDOUS WASTE FACILITY

9.1 Introduction

The following section categorises and identifies the single environmental aspects, which have informed the list of ***pertinent*** issues, which have been identified by specialist research, I&AP representation and the assessment evaluation. These listed issues have been determined through the environmental impact assessment, the scoping process, the public participation process and the site visit.

Impacts identified would be divided into impacts that could occur during the planning and design phase, construction phase, operation phase and the rehabilitation phase.

9.2 Impacts related to the Hazardous Waste Facility (See Appendix H)

The following list of issues has been determined through the assessment process based on the environmental baseline descriptions in section 4 and the public participation process in section 5.

9.2.1 Issues identified for the planning and design phase

HAZARDOUS WASTE HANDLING FACILITY Planning and Design phase		
Environmental Features	**Activity**	**Description of potential impact**
Air quality	o Road surface of internal road o Treatment processes o Location of construction camp	o Dust generation o Noise o Emissions of pollutants o Human health
Water o Groundwater quality o Potable water sources o Stormwater run-off o Drainage line flows o Movene River	o High rainfall o Seismic activity o Treatment processes o Infrastructure design o Storage of unknown hazardous waste o Choice of construction materials (Geosynthetic liner included)	o Natural flooding regime of the Movene River catchment area - flooding o Pollution and siltation of water bodies o Pollution of potable water sources – springs/wells o Human health o Leachate permeating through liner - pollution
Geology, soils and change in landform	o Infrastructure design o Stormwater management o Construction camp Location	o Change in visual/ aesthetics of the area o Erosion o Destruction of fauna and flora
Socio-economic o Relocation of Machambas	o Location of potential facility o Placement of	o Loss of grazing and arable land o Loss of resources o Loss of cultivated Machambas

o Resettlements of households o Development plan / pattern for Mavoco o Surrounding community members	construction camp o Placement of quarry o Settlement in surrounding area o Buffer zone around facility o Education of surrounding community	o Loss of crops o Conflicts in landuse o Encroachment o Health and safety

9.2.2 Issues identified for the construction phase

HAZARDOUS WASTE HANDLING FACILITY Construction phase		
Environmental Features	**Activity**	**Description of potential impact**
Air quality	o Clearing and grubbing o Blasting o Construction Vehicle movement o Heavy vehicles to and from quarry site o Quarry activities	o Dust generation o Noise o Safety of road users o Safety of community
Water o Water quality (run-off) o Water quantity o Stormwater run-off o Drainage line flows	o Material storage o Mixing of concrete o Maintenance o Construction camp and vehicles (run-off)	o Natural flooding regime of the Movene River catchment area o Pollution and siltation of water bodies o Pollution of potable water sources
Geology and soils	o Blasting o Trenching o Construction material storage o Vehicular movement o Rehabilitation	o Change in geological patterns / structure / fissuring o Compaction of soils o Erosion o Dust o Agricultural potential
Natural vegetation	o Storage of construction materials o Clearing of topsoil and grubbing o Vehicular movement and access o Trenching o Rehabilitation	o Destruction and loss of natural vegetation cover o Mixing of topsoil and subsoil o Loss of vegetative layer for rehabilitation o Erosion control o Loss of grazing
Fauna species	o Blasting o Vehicular movement o Clearing and grubbing o Trenching o Construction of residential houses o Construction staff activities	o Noise o Safety o Potential displacement of birds and small mammals o Destruction and loss of natural habitat

Cultural / historical	o Trenching o Vehicular movement o Building materials for houses / fences	o Destruction of graves and archaeological sites
Socio-economic		
o Harvesters of firewood and charcoal o Neighbouring community o Pedestrians	o Blasting o Trenching o Vehicular movement o Construction camp o Construction of infrastructure	o Noise pollution o Air pollution o Disruption in social structure o Limited/ prohibited access to the site o Employment opportunities
Infrastructure o Electricity supply o Water & sewage supply o Roads	o Clearing and grubbing o Blasting o Construction Vehicle movement o Trenching o Construction camp	o Noise pollution o Air pollution o Safety of surrounding community o Access to Machambas and houses o Destruction of fauna and flora species

9.2.3 Issues identified for the operational phase

HAZARDOUS WASTE HANDLING FACILITY Operational phase		
Environmental Features	**Activity**	**Description of potential impact**
Air quality	o Road surface of internal road o Treatment processes o Temporary storage of hazardous waste	o Dust o Emissions of pollutants o Human health o Obnoxious odours
Water o Groundwater quality o Potable water sources o Stormwater run-off o Drainage line flows o Movene River	o High rainfall - flooding o Seismic activity o Treatment processes o Infrastructure maintenance o Storage of unknown hazardous waste o Maintenance of Liner	o Pollution of water bodies o Pollution of potable water sources – springs/wells o Human health o Leachate permeating through liner – pollution
Fauna and flora in the surrounding area	o Treatment processes of hazardous waste o Spills and disasters o Resettlement or pollution of fauna in the area	o Reduction in crop quality o Reduction in crop quantity o Noise o Loss of resources for food or income
Socio-economic o Development plan / pattern for Mavoco	o Access control to the facility o Treatment processes o Settlement in surrounding	o Loss in crop quality and quantity o Conflicts in landuse

o Surrounding community members o Workers at the facility and transporters of waste	area o Maintenance of Buffer zone around facility o Education of surrounding community	o Encroachment o Health and safety

9.2.4 Issues identified for the rehabilitation phase

HAZARDOUS WASTE HANDLING FACILITY Decommissioning and Rehabilitation phase		
Environmental Features	**Activity**	**Description of potential impact**
Air quality	o Final capping of landfill o Construction activities and vehicle movement o Gasses from stored waste o Combustion of flammable waste	o Dust generation o Odour o Emissions of pollutants o Human health
Water o Groundwater quality o Potable water sources o Stormwater run-off o Drainage line flows o Movene River	o High rainfall o Seismic activity o Rapture of liner - Leachate permeating through liner	o Pollution of water bodies o Pollution of potable water sources – springs/wells o Human health o Fauna and flora
Change in landform	o Final height of landfill capsule	o Change in visual/ aesthetics of the area
Socio-economic o Agricultural potential o Surrounding community members	o Landscaping o Rehabilitation o Resource harvesting	o Conflicts in landuse o Production of crops o Encroachment o Health and safety

9.3 Impact Matrix

The following matrix was used to determine possible impacts of the proposed Mavoco Hazardous Waste Facility on the environment. All the construction phase issues were not listed in the previous section as they relate to construction activities and methods. The Construction phase of the Environmental Management Plan would deal with these impacts to ensure that they are mitigated as far as possible.

9.4 Pertinent issues, impact evaluation and mitigation

The above issues and comments were disseminated and categorised into issues of similar nature, to consolidate the assessment evaluation process. The assessments are environmentally focused with descriptions of the activity impacts included within each evaluation type.

ENVIRONMENTAL DESCRIPTION:

Dust generation

Impact Description:

Construction phase: Construction activities such as clearing and grubbing, topsoil removal, trenching and storage as well as the movement of construction vehicles generate dust. The dust will influence the air quality in the immediate vicinity of the construction activity.

Operational phase: Transportation vehicles and other road users could generate dust if the road surface is gravel /or if other surfaces are not maintained.

If the air quality exceed accepted standards, the neighbouring community as well as construction workers could experience health problems.

Impact Significance	Description	Summary
Nature and Extent	The impact will be restricted to the construction site.	Immediate site
Duration – Construction phase	The impact will be of short duration, limited to construction phase.	Short term
Duration – Operational phase	The impact will be long term.	Long term
Status and Intensity	The intensity of the impact will be moderate, but it could be mitigated with proper planning.	Medium
Probability	The impact will be probable and all mitigation and construction requirements are to be instituted in improving and maintaining the status quo of the air quality.	Probable
Significance	The impact **if not** mitigated will have high significance. It is imperative that the mitigation and recommendation as stipulated in the EMP, be implemented.	High
Weighted Value	**Measurable impact on the environment**	

Mitigation

Construction phase:

- Regular wetting of soil to reduce dust.
- Construction activities to disturb as little area as possible – natural vegetation to be left as erosion protection.
- Construction workers to follow prescribed precautions when working in dusty conditions.

Operational phase:

- The road surface should be maintained regularly to eliminate potholes.

ENVIRONMENTAL DESCRIPTION:

Air pollution

Impact Description:

Operational phase:
Spillages of hazardous waste on site as well as treatment of the hazardous waste could cause air pollution. Combustible materials could burst into flames and the burning of these materials could release toxic gasses and obnoxious odours.

If the air quality exceed accepted standards, the neighbouring community, animals as well as workers at the facility could experience health problems.

Impact Significance	Description	Summary
Nature and Extent	The impact will not be restricted to the construction site, depending on wind direction.	Local area
Duration	The impact will be medium term depending on wind and treatment procedures.	Medium term
Status and Intensity	The intensity of the impact will be moderate, but it could be mitigated with proper planning.	Medium
Probability	The impact will be probable and all mitigation and construction requirements are to be instituted in improving and maintaining the status quo of the air quality.	Probable
Significance	The impact **if not** mitigated will have high significance. It is imperative that the mitigation and recommendation as stipulated in the EMP, be implemented.	High
Weighted Value	**Measurable impact on the environment**	

Mitigation

- The design of the facility and infrastructure must ensure that treatment processes that could cause air pollution are contained.
- Emergency procedures should be in place to reduce the impact of materials spilled or that could cause fire.
- Fire fighting equipment should be checked regularly and maintained.
- Air quality monitoring should take place regularly as stipulated in the EMP.

ENVIRONMENTAL DESCRIPTION:		
Noise		
Impact Description:		
Construction phase: Noise is generated by construction activities such as clearing and grubbing, layer works, trenching and cement batching. Construction vehicles generate noise and quarrying for construction materials could also generate noise. Operational phase: Noise is generated by the surface and maintenance of the internal road. Transportation vehicles and other vehicles travelling on the road will cause noise depending on the condition and design of the road. Excessive noise could have an impact on the neighbouring community, construction and facility workers as well as the animals in the area.		
Impact Significance	**Description**	**Summary**
Nature and Extent	The impact will be restricted to the site as well as the surrounding area.	Local
Duration – Construction phase	The impact will be of short duration, limited to construction phase.	Short term
Duration – Operational phase	The impact will be long term, throughout the operational phase of the road.	Long term
Status and Intensity	The intensity of the impact will be moderate, but it could be mitigated with proper planning.	Moderate
Probability	The impact will be probable and all mitigation and construction requirements are to be instituted in improving and maintaining the status quo of the noise levels.	Probable
Significance	The impact **if not** mitigated will have medium significance. It is imperative that the mitigation and recommendation stipulated in the EMP be implemented.	Medium
Weighted Value	**Measurable impact on the environment**	
Mitigation		
Construction phase: o Construction workers to adhere to health and safety standards as prescribed in the EMP. o Working hours should be restricted to reduce impacts on the neighbouring community at night. o All machinery and plant to conform to Regional noise reduction standards. o All plant to be provided with effective mufflers. **Operational phase:** o Regular maintenance of the road to ensure road safety and to reduce noise as a result of potholes and vehicles reducing speed to avoid them.		

ENVIRONMENTAL DESCRIPTION:		
Soil, Groundwater and Surface water pollution		
Impact Description:		
Construction phase: Construction activities such as clearing and grubbing, topsoil removal, trenching and storage of materials could cause erosion during rainstorms or flooding. Erosion of the soil or run-off from construction materials could cause siltation of the water bodies in the surrounding area. Construction vehicles, which are not well maintained, spill fuel and oil that could pollute the soil and water. The location of the construction camp as well as the quarry for construction materials should be considered carefully to minimise potential impacts on soil and water bodies. Operational phase: If the treatment of the hazardous waste at the facility is not adequate, leachate could permeate through the liner of the landfill. If the liner is not designed to handle all the different types of waste treated at the facility, then the effectiveness of the liner could be compromised. Seismic activity on the site could cause the liner to rupture and leachate could pollute the groundwater. Stormwater drainage on site should be adequate to deal with flooding and to divert hazardous materials being swept from the protective liner into the surrounding environment. Pollution of the soil could impact on the vegetation and reduce the quality and quantity of crops in the area. Pollution of the water sources could cause environmental disasters or impact on the health of the neighbouring community, construction and facility workers. Potable water in the area is a scarce resource and valuable.		
Impact Significance	**Description**	**Summary**
Nature and Extent	The impact will not be restricted to the construction site.	Local or regional
Duration – Construction phase	The impact will be of short duration, limited to construction phase.	Short term
Duration – Operational phase	The impact will be long term.	Long term
Status and Intensity	The intensity of the impact will be high, but it could be mitigated with proper planning.	High
Probability	The impact will be probable and all mitigation and construction requirements are to be instituted to prevent pollution.	Probable
Significance	The impact **if not** mitigated will have high significance. It is imperative that the mitigation and recommendation as stipulated in the EMP, be implemented.	High
Weighted Value	**High impact on the environment**	
Mitigation		

Construction phase:

- The location of topsoil and other construction material stockpiles must be carefully considered to minimise siltation / pollution of water sources.
- These stockpiles must be clearly demarcated and stabilised to ensure minimum erosion during rainstorms.
- Construction activities to disturb as small an area as possible – natural vegetation to be left as erosion protection.
- Construction vehicles must be maintained regularly and services conducted in clearly demarcated service areas designed to contain fuel and oil spillages.

Operational phase:

- The road surface should be maintained regularly to minimise accidents and spillages of hazardous waste.
- Transportation vehicles of hazardous waste must be maintained regularly and should adhere to international standards for the transportation of hazardous waste.
- The design of the liner for the landfill must be adequate to contain all the hazardous waste.
- Treatment processes at the facility must ensure that the liner is not compromised.
- Monitoring boreholes must be determined scientifically and monitoring should take place regularly in order to ensure that possible pollution of the soil and groundwater is detected as soon as possible to minimise the impact on the environment.
- Emergency plans must be in place and implemented should spillages or other disasters occur during the treatment of the hazardous waste at the facility.
- Drivers of vehicles that transport hazardous waste as well as emergency personnel should be properly educated to ensure that they know how to deal with potential situations that could impact on the environment and the safety of the neighbouring community.

ENVIRONMENTAL DESCRIPTION:		
Construction Camp and site offices		
Impact Description:		
The construction camp and site offices could have an impact on the environment if the placement or design is poorly situated. Domestic waste as well as construction waste generated at the construction camp could also impact on the fauna and flora in the area as well as the human health of construction workers and the community if it is not removed to a landfill site.		
Impact Significance	**Description**	**Summary**
Nature and Extent	The impact will be restricted to the construction site.	Immediate site
Duration	The impact will be of short duration, limited to construction phase.	Short term
Status and Intensity	The intensity of the impact will be moderate, but it could be mitigated with proper planning.	Medium
Probability	The impact will be probable and all mitigation and construction requirements are to be instituted.	Probable
Significance	The impact **if not** mitigated will have high significance. It is imperative that the mitigation and recommendation as stipulated in the EMP, be implemented.	High
Weighted Value	**Measurable impact on the environment**	
Mitigation		
o Only one construction camp should be established for the facility as well as the access road. o The placement of the construction camp should preferably be on the facility site and must be negotiated with the landowner. o The construction camp must be placed on a disturbed piece of land. o Indigenous vegetation must not be disturbed if at all possible. o The contractor must supply the workers with firewood or preferably gas cooking appliances, to ensure that wood is not taken from the surrounding area.		

drinking-water

ENVIRONMENTAL DESCRIPTION:		
Social impact: Relocation of Machambas and resettlement		
Impact Description:		
Construction phase: Mavoco is a small rural community dependant on crops production on small machambas or plots. The construction of the road would influence the community members that have settled and developed machambas within the area of the site. The loss of machambas would force these people to relocate to other areas and to start from the beginning, clearing the land to cultivate it for crop production. Timing for the resettlement is crucial since these people are dependant on the growing season to produce their food. If they are moved before they have harvested their crops, they will not have food for the coming winter months or seed for the following growing season.		
Impact Significance	**Description**	**Summary**
Nature and Extent	The impact will be restricted to the construction area.	Local area
Duration	The impact will be medium term, not limited to the construction phase. It could have an impact during the following growing seasons.	Medium term
Status and Intensity	The intensity of the impact will be moderate, but it could be mitigated with proper planning.	Medium
Probability	The impact will be highly probable.	Highly probable
Significance	The impact **if not** mitigated will have high significance. It is imperative that the mitigation and recommendation as stipulated in the EMP, be implemented.	High
Weighted Value	**Medium impact on the environment**	
Mitigation		
○ Comprehensive compensation and resettlement programs should be developed and implemented to reduce the impact on the affected people. ○ Compensation for relocation of machambas or resettlement of households should eliminate conflicts and ensure that the community is not impacted negatively. ○ Skills transfer/training and equipment should be provided to ensure that the affected people are resettled and relocated as soon as possible and could continue with their daily activities.		

ENVIRONMENTAL DESCRIPTION:		
Social impact: Loss of land for grazing, resources and loss of arable land		
Impact Description:		
Construction phase: Mavoco is a small rural community dependant on crops produced on small machambas or plots. They are dependant on the surrounding area for resources such as firewood, charcoal and small animals. The construction of the facility would reduce these resources and construction activities could impact on the fauna of the area. Reduction in resources would cause a reduction in income from the selling of firewood, charcoal and hunted fauna. Loss of arable land and land for grazing could reduce farming activities and essential food production.		
Impact Significance	**Description**	**Summary**
Nature and Extent	The impact will be restricted to the construction site.	Local area
Duration	The impact will be medium term, not limited to the construction phase. It could have an impact during the following seasons	Medium term
Status and Intensity	The intensity of the impact will be moderate, but it could be mitigated with proper planning.	Medium
Probability	The impact will be probable. .	Probable
Significance	The impact **if not** mitigated will have high significance. It is imperative that the mitigation and recommendation as stipulated in the EMP, be implemented.	High
Weighted Value	**Medium impact on the environment**	
Mitigation		
o Comprehensive compensation and resettlement programs should be developed and implemented to reduce the impact on the affected people. o Resources should be made available to the local community if the resources are to be cleared for the construction of the facility.		

ENVIRONMENTAL DESCRIPTION:		
Social impact: Employment and Skills transfer		
Impact Description:		
Construction phase: Mavoco is a small rural community with limited developments contributing to job creation. The construction of the facility would increase opportunities for skills development in the area. Contractors should be encouraged to use or train local unskilled labour, where possible. The increased skills development could be used in future developments in the area, uplifting the people and improving the economy of the region. Operational phase: The new access road to the facility would also encourage other businesses / industries to settle in the surrounding area. A buffer of industries should be encouraged to establish around the facility to minimise pollution effects on the surrounding community. These new settlement patterns could however impact on the local agricultural community and reduce available arable land for cultivation.		
Impact Significance	**Description**	**Summary**
Nature and Extent	The impact will not be restricted to the construction site.	Local area
Duration	The impact will be long term, not limited to the construction phase.	Long term
Status and Intensity	The intensity of the impact will be moderate, but it could be mitigated with proper planning.	Medium
Probability	The impact will be probable and employment opportunities are positive.	Probable
Significance	The impact **if not** mitigated will have high significance. It is imperative that the mitigation and recommendation as stipulated in the EMP, be implemented.	High
Weighted Value	**Positive impact on the environment**	
Mitigation		
○ Local labour (woman included) should be used as far as possible during the construction of the facility through a local labour recruitment plan. ○ Establish mechanisms and structures to ensure the appropriate development and transfer of skills to the local community. ○ An overall development / landuse plan for the surrounding area should be implemented to ensure that potential future conflicts are identified and mitigated.		

10 IMPACT EVALUATION AND MITIGATION - ACCESS ROAD

10.1 Introduction

The following section categorises and identifies the single environmental aspects, which have informed the list of ***pertinent*** issues, which have been identified by specialist research, I&AP representation and the assessment evaluation. These listed issues have been determined through the environmental impact assessment, the scoping process, the public participation process and the site visit.

Impacts identified would be divided into impacts that could occur during the planning and design phase, construction phase, operation phase and the rehabilitation phase.

10.2 Impacts related to the Access Road (See Appendix H)

The following list of issues has been determined through the assessment process based on the environmental baseline descriptions in section 4 and the public participation process in section 5.

10.2.1 Issues identified for the planning and design phase

ACCESS ROAD Planning and Design phase		
Environmental Features	**Activity**	**Description of potential impact**
Air quality	o Surfacing of access road o Location of construction camp	o Dust generation o Noise o Human health
Water o Groundwater quality o Potable water sources o Stormwater run-off	o High rainfall o Storage of construction materials o Location of construction camp o Location of borrow pit	o Erosion of soil o Pollution and siltation of water bodies o Pollution of potable water sources – springs/wells o Human health
Geology, soils and change in landform	o Route design o Stormwater management o Location of construction camp	o Change in visual/ aesthetics of the area o Erosion o Destruction of fauna and flora
Socio-economic o Relocation of Machambas o Resettlements of households o Development plan / pattern for Mavoco o Surrounding community members	o Location of construction camp o Placement of borrow pit o Settlement patterns next to road o Compensation for loss of Machambas	o Loss of grazing and arable land o Loss of resources o Loss of cultivated Machambas o Loss of crops o Conflicts in community o Conflicts in landuse o Encroachment o Health and safety o Employment opportunities

10.2.2 Issues identified for the construction phase

ACCESS ROAD Construction phase		
Environmental Features	**Activity**	**Description of potential impact**
Air quality	o Clearing and grubbing o Blasting o Construction Vehicle movement o Heavy vehicles to and from borrow pit site o Borrow pit activities	o Dust generation o Noise o Safety of road users o Safety of community
Water o Water quality (run-off) o Water quantity o Stormwater run-off o Drainage line flows	o Material storage o Mixing of concrete o Maintenance o Construction camp and vehicles (run-off)	o Natural flooding regime of the Movene River catchment area o Pollution and siltation of water bodies o Pollution of potable water sources
Geology and soils	o Blasting o Trenching o Construction material storage o Vehicular movement o Rehabilitation	o Change in geological patterns / structure / fissuring o Compaction of soils o Erosion o Dust o Agricultural potential
Natural vegetation	o Storage of construction materials o Clearing of topsoil and grubbing o Vehicular movement and access o Trenching o Rehabilitation	o Destruction and loss of natural vegetation cover o Mixing of topsoil and subsoil o Loss of vegetative layer for rehabilitation o Erosion control o Loss of grazing
Fauna species	o Blasting o Vehicular movement o Clearing and grubbing o Trenching o Construction of residential houses o Construction staff activities	o Noise o Safety o Potential displacement of birds and small mammals o Destruction and loss of natural habitat
Cultural / historical	o Trenching o Vehicular movement o Building materials for houses / fences	o Destruction of graves and archaeological sites
Socio-economic		
o Harvesters of firewood and charcoal. o Neighbouring community	o Blasting o Trenching o Vehicular movement o Construction camp	o Health and safety o Noise pollution o Air pollution o Disruption in social

o Pedestrians	o Construction of infrastructure	structure o Limited/ prohibited access to the site o Employment opportunities

10.2.3 Issues identified for the operational phase

ACCESS ROAD Operational phase		
Environmental Features	**Activity**	**Description of potential impact**
Air quality	o Transportation of hazardous waste o Access route for neighbouring communities o Spills and disasters	o Dust o Emissions of pollutants o Human health o Obnoxious odours o Pollution of crops and natural vegetation
Water o Stormwater run-off o Drainage line flows o Movene River	o High rainfall - flooding o Maintenance of road o Transportation of hazardous waste o Accidents, spills and disasters	o Pollution of water bodies o Pollution of potable water sources – springs/wells o Human health o Reduction in crop quality and quantity
Fauna and flora in the surrounding area	o Transportation of hazardous waste o Accidents, spills and disasters	o Reduction in crop quality and quantity o Noise o Loss of resources as extra protein/income
Socio-economic o Development plan / pattern for Mavoco o Surrounding community members o Drivers of transport vehicles	o Settlement in surrounding area o Education of surrounding community	o Loss in crop quality and quantity o Conflicts in landuse o Encroachment o Health and safety

10.3 Impact Matrix

The following matrix was used to determine possible impacts of the proposed access road on the environment. All the construction phase issues were not listed in the previous section as they relate to construction activities and methods. The Construction phase of the Environmental Management Plan would deal with these impacts to ensure that they are mitigated as far as possible.

10.4 Pertinent issues, impact evaluation and mitigation

The above issues and comments were disseminated and categorised into issues of similar nature, to consolidate the assessment evaluation process. The assessments are environment focused with descriptions of the activity impacts included within each evaluation type.

ENVIRONMENTAL DESCRIPTION:

Dust generation

Impact Description:

Construction phase: Construction activities such as clearing and grubbing, topsoil removal, trenching and storage as well as the movement of construction vehicles generate dust. The dust will influence the air quality in the immediate vicinity of the construction activity.

Operational phase: Transportation vehicles and other road users could cause dust if the road surface is gravel /or if other surfaces is not maintained.

If the air quality exceed accepted standards, the neighbouring community as well as construction workers could experience health problems.

Impact Significance	Description	Summary
Nature and Extent	The impact will be restricted to the site including the surrounding area.	Local
Duration – Construction phase	The impact will be of short duration, limited to construction phase.	Short term
Duration – Operational phase	The impact will be long term	Long term
Status and Intensity	The intensity of the impact will be moderate, but it could be mitigated with proper planning.	Medium
Probability	The impact will be probable and all mitigation and construction requirements are to be instituted in improving and maintaining the status quo of the air quality.	Probable
Significance	The impact **if not** mitigated will have high significance. It is imperative that the mitigation and recommendation as stipulated in the EMP, be implemented.	High
Weighted Value	**Measurable impact on the environment**	

Mitigation

Construction phase:

- Regular wetting of sandy soil to reduce dust
- Construction activities to disturb as small an area as possible – natural vegetation to be left as erosion protection.
- Construction workers to follow prescribed precautions when working in dusty conditions.

Operational phase:

- The road surface should be maintained regularly to eliminate potholes.

ENVIRONMENTAL DESCRIPTION:

Noise

Impact Description:

Construction phase: Noise is generated by construction activities such as clearing and grubbing, layerworks and trenching.

Operational phase: Noise is generated by the surface and maintenance of the road. Transportation and other vehicles travelling on the road will cause noise depending on the condition and design of the road.

Excessive noise could have an impact on the neighbouring community, construction workers as well as the animals in the area.

Impact Significance	Description	Summary
Nature and Extent	The impact will be restricted to the site as well as the surrounding area.	Local
Duration – Construction phase	The impact will be of short duration, limited to construction phase.	Short term
Duration – Operational phase	The impact will be long term, throughout the operational phase of the road.	Long term
Status and Intensity	The intensity of the impact will be moderate, but it could be mitigated with proper planning.	Moderate
Probability	The impact will be probable and all mitigation and construction requirements are to be instituted in improving and maintaining the status quo of the noise levels.	Probable
Significance	The impact **if not** mitigated will have medium significance. It is imperative that the mitigation and recommendation stipulated in the EMP be implemented.	Medium
Weighted Value	**Measurable impact on the environment**	

Mitigation

Construction phase:

- Construction workers to adhere to health and safety standards as prescribed in the EMP.
- Working hours should be restricted to reduce impacts on the neighbouring community at night.
- All machinery and plant to conform to Regional noise reduction standards.
- All plant to be provided with effective mufflers.

Operational phase:

- Regular maintenance of the road to ensure road safety and to reduce noise as a result of potholes and vehicles reducing speed to avoid them.

ENVIRONMENTAL DESCRIPTION:		
Soil, Groundwater and Surface water pollution		
Impact Description:		
Construction phase: Construction activities such as clearing and grubbing, topsoil removal, trenching and storage of materials could cause erosion during rainstorms or flooding. Erosion of the soil or run-off from construction materials could cause siltation of the water bodies in the surrounding area. Construction vehicles, which are not well maintained, spill fuel and oil that could pollute the soil and water. The location of the construction camp as well as the borrow pit for road materials should be considered carefully to minimise potential impacts on soil and water bodies. Operational phase: Transportation vehicles of hazardous waste and other road users could spill waste, fuel or oil on the road surface or next to the road that could pollute the soil and ground/surface water. Pollution of the soil could impact on the vegetation and reduce the quality and quantity of crops in the area. Pollution of the water sources could cause environmental disasters or impact on the health of the neighbouring community as well as construction workers.		
Impact Significance	**Description**	**Summary**
Nature and Extent	The impact will not be restricted to the construction site.	**Local or regional**
Duration – Construction phase	The impact will be of short duration, limited to construction phase.	Short term
Duration – Operational phase	The impact will be long term.	Long term
Status and Intensity	The intensity of the impact will be high, but it could be mitigated with proper planning.	High
Probability	The impact will be probable and all mitigation and construction requirements are to be instituted to prevent pollution.	Probable
Significance	The impact **if not** mitigated will have high significance. It is imperative that the mitigation and recommendation as stipulated in the EMP, be implemented.	High
Weighted Value	**High impact on the environment**	
Mitigation		

Construction phase:

- The location of Topsoil and other construction material stockpiles must be carefully considered to minimise siltation / pollution of water sources.
- These stockpiles must be clearly demarcated and stabilised to ensure minimum erosion during rainstorms.
- Construction activities to disturb as small an area as possible – natural vegetation to be left as erosion protection.
- Construction vehicles must be maintained regularly and services conducted in clearly demarcated service areas designed to contain fuel and oil spillages.

Operational phase:

- The road surface should be maintained regularly to minimise accidents and spillages of hazardous waste.
- Transportation vehicles of hazardous waste must be maintained regularly and should adhere to international standards for the transportation of hazardous waste.
- Monitoring of surrounding water sources must take place regularly in order to ensure that possible pollution of ground and surface water is detected as soon as possible to minimise the impact on the environment.
- Emergency plans must be in place and implemented should spillages or other disasters occur during the transportation of the hazardous waste.
- Drivers of vehicles that transport hazardous waste as well as emergency personnel should be properly educated to ensure that they know how to deal with potential situations that could impact on the environment and the safety of the neighbouring community.

ENVIRONMENTAL DESCRIPTION:		
Social impact: Relocation of Machambas and resettlement		
Impact Description:		
Construction phase: Mavoco is a small rural community dependant on crops production on small machambas or plots. The construction of the road would influence the community members that have settled and developed machambas within the area of the site. The loss of machambas would force these people to relocate to other areas and to start from the beginning, clearing the land to cultivate it for crop production. Timing for the resettlement is crucial since these people are dependant on the growing season to produce their food. If they are moved before they have harvested their crops, they will not have food for the coming winter months or seed for the following growing season.		
Impact Significance	**Description**	**Summary**
Nature and Extent	The impact will be restricted to the construction site.	Local area
Duration	The impact will be medium term, not limited to the construction phase. It could have an impact during the following growing seasons.	Medium term
Status and Intensity	The intensity of the impact will be moderate, but it could be mitigated with proper planning.	Medium
Probability	The impact will be highly probable.	Highly probable
Significance	The impact **if not** mitigated will have high significance. It is imperative that the mitigation and recommendation as stipulated in the EMP, be implemented.	High
Weighted Value	**Medium impact on the environment**	
Mitigation		
○ Comprehensive compensation and resettlement programs should be developed and implemented to reduce the impact on the affected people. ○ Care should be taken with the route alignment to ensure that machambas and households relocated during the development of Mozal are avoided as far as possible, to eliminate second relocations. ○ Compensation for relocation of machambas or resettlement of households should eliminate conflicts and ensure that the community is not impacted negatively. ○ Skills transfer/training and equipment should be provided to ensure that the affected people are resettled and relocated as soon as possible and could continue with their daily activities.		

ENVIRONMENTAL DESCRIPTION:		
Social impact: Loss of land for grazing, resources and loss of arable land		
Impact Description:		
Construction phase: Mavoco is a small rural community dependant on crops produces on small machambas or plots. They are dependant on the surrounding area for resources such as firewood, charcoal and small animals. The construction of the road would reduce these resources and construction activities could impact on the fauna of the area. Reduction in resources would cause a reduction in income from the selling of firewood, charcoal and hunted fauna. Loss of arable land and land for grazing could reduce farming activities and essential food production.		
Impact Significance	**Description**	**Summary**
Nature and Extent	The impact will be restricted to the construction site.	Local area
Duration	The impact will be medium term, not limited to the construction phase. It could have an impact during the following seasons.	Medium term
Status and Intensity	The intensity of the impact will be moderate, but it could be mitigated with proper planning.	Medium
Probability	The impact will be probable.	Probable
Significance	The impact **if not** mitigated will have high significance. It is imperative that the mitigation and recommendation as stipulated in the EMP, be implemented.	High
Weighted Value	**Medium impact on the environment**	
Mitigation		
○ Comprehensive compensation and resettlement programs should be developed and implemented to reduce the impact on the affected people. ○ Resources should be made available to the local community if the resources are to be cleared for the construction of the road. Clearing should be kept to a minimum.		

11 CONCLUSION AND RECOMMENDATIONS

The significant impacts identified through the above process are listed below.

- Dust generation
- Noise
- Emissions of pollutants
- Impacts on the natural flooding regime of the Movene River catchment area
- Pollution and siltation of water bodies
- Pollution of potable water sources – springs/wells
- Leachate permeating through liner – pollution
- Change in visual/ aesthetics of the area
- Erosion
- Destruction of fauna and flora
- Loss of grazing and arable land
- Loss of resources
- Loss of cultivated Machambas
- Reduction in crop quality and quantity
- Conflicts in landuse
- Encroachment
- Health and safety
- Risk of major spills and environmental disasters

11.1 Conclusion and recommendation for the Hazardous Waste Facility:

The status quo "no-go" situation that currently occurs in Mozambique could result in major environmental damage over the long run. Cleaning this waste and rehabilitating the environment, transferring hazardous waste and treatment of the waste is becoming increasingly costly. Spillages and impacts associated with hazardous waste could only become known (without regular monitoring), years after it took place and by that time it could be to late to prevent a major disaster. It is therefore recommended that the no-go alternative not be investigated further.

With proper planning and design of the facility to accommodate mitigation measures into environmental management of the facility, the environmental and social risk associated with hazardous waste could be limited. The existing situation for disposal of hazardous waste in Mozambique and the associated potential risk to human health and the environment could only improve with the development of a hazardous waste facility.

Facility treatment processes:

The proposed process of waste stabilization with cement or lime is supported as it is expected to reduce the mobility of the hazardous constituents within the waste and that it will make the waste easier to manage. Apart from the temporary storage of waste in the transfer area, the guidelines as set out in the Minimum Requirements have been followed and all aspects of a thorough design are represented in the Mavoco hazardous waste disposal facility.

The **Gaseous Impacts** assessment for the facility revealed no need to develop any community buffer zones based on health impacts.

Recommendation:

- Control of the waste stream would be required at all times from where it is collected at the source and transported to the landfill facility. Proper transportation equipment and vehicles would be required to convey the waste to the landfill and which will be travelling on a durable and surfaced roadway. The intention is to limit the possibility of any spillage of the waste on-route to the waste disposal facility.
- A detailed seismic risk assessment of the site must be conducted and if required, the landfill cells and structures must be designed for such a hazard.
- The regional and site geology must be reviewed and a map must be produced indicating the site geology, dykes, faults, etc of the site.
- It is recommended that the expansive potential of the soil profiles be reassessed.
- It is recommended that investigations regarding drilling, modelling and water analyses be completed to fully understand and manage the Mavoco facility.
- An ongoing monitoring programme must be implemented before construction activities commence (status quo determination), to determine potential pollution of ground and surface water.
- A buffer zone (without residential development) of between 100 m and 300 m must be established around the facility to mitigate **Odour** impacts and odour management.
- An ongoing monitoring programme must be implemented before construction activities commence (status quo determination), to determine potential air pollution.
- A suitably qualified operating company should manage the operations of the facility.
- Treatment procedures for the hazardous waste should be established before the construction of the facility.
- Detailed emergency plans for spillages and disasters at the facility as well as on the access road must be developed before the operation phase.
- A policy on temporary storage should be developed before storage of waste, where no treatment plan has been established.
- Only one construction camp should be developed for the facility to reduce potential impacts.
- The development of the hazardous waste facility should be accompanied by a overall development/land use plan for the surrounding area to ensure that any potential future conflicts regarding land use inherent in future projects in the area are identified and mitigated as quickly as possible.
- A zoning plan should be developed for the area around the hazardous waste facility that takes into consideration the requirements of local communities and provides a vision of what types of development shall be permitted in future.
- A comprehensive compensation and resettlement plan should be developed for the project as soon as possible. Compensation and resettlement should be handled with the highest degree of sensitivity and the project should avoid, in the planning phase, compensating or relocating people who have already been relocated due to other projects.
- Resettlement plans should not be limited to simple land attribution but include support to the local population in relationship to land clearance, seed stock and agricultural extension services, in accordance with World Bank guidelines on compensation and resettlement.

11.2 Conclusion and recommendations for the Access Road

Surfacing of the Access Road:

It is recommended that alternative 2: Emulsion stabilised sand road be used for the access road. This will ensure improved vehicular safety and less noise with no dust. This alternative will have the following benefits:

- Dust associated with gravel roads, that could influence the health of persons living next to the road will be limited.
- Dust associated with gravel roads, that could reduce crop production and/or influence the quality of the crops will be limited.
- Noise associated with gravel roads will be reduced.
- Road safety will increase for the safe transportation of waste, decreasing risk of spillages and environmental damage.

Early Access Road:

It is recommended that the early access road not be considered as an alternative and that the alignment chosen for the permanent access route also be utilized for the early construction access route. By following the same alignment, potential environmental and social impacts are minimized and concentrated along a single axis rather than distributed and duplicated.

Route Alignment for the Access Road

The Moamba – Boane route alternative has less social cost associated with the route, but much higher impacts relating to transportation cost and the potential for spillage and major environmental disasters.

The Motraco route alternative does have social implications relating to relocation and compensation for machambas in terms of loss in income, relocation cost as well as loss of prepared machambas. Mitigation measures to deviate around formal machambas, that have already been relocated during the implementation of the Mozal project and around a low laying marshy area, ensures that the social cost associated with relocation is not of high significance.

It is clear that the social cost associated with the Motraco route alternative is outweighed against the environmental risk and escalating transportation cost of the Moamba-Boane road. It is therefore recommended that Alternative 2 following the Motraco transmission line with two deviations is the preferred alternative for the proposed access road. Alternative 3 should be investigated in much more detail if this option is to be considered in the future.

It is quite evident from the environmental assessment, with specific reference to the detailed specialist studies and the social studies that the selected Mavoco site for the establishment of the hazardous waste treatment facility, and the access road have certain definite opportunities and constraints. The ultimate purpose of this analysis and evaluation process is to ensure that the constraints do not out weight the opportunities, and that the "allowable" environmental and social constraints / costs of the project do not compromise the existing social and environmental integrity. Within this framework the following conclusion is made - The site is suitable for the proposed development, providing the above recommendations is taken into consideration.

It would be imperative to finalise the results of the above to provide full confidence of the long term sustainability of the facility.

Design criteria	Beluluane hazardous waste facility	May 2002	MDD 0455-G-001
Technical report	Draft report on the hydrological investigation undertaken for the proposed Beluluane hazardous waste facility - Mozambique	September 2002	GCS – 02.04-094
Report	Evaluation of alternative site and public participation	October 2001	SEED
Report	Geological and Hydrogeological investigation of two areas pre-selected for the construction of a treatment facility including a secure landfill for hazardous waste.	July 2001	Department of Applied Geology – Ministerio Dos Recursos Minerais E Energia
Guidelines	Hazardous waste management in Mozambique – System description	September 2001	MICOA – DNAIA
Report	Implementation study report	June 2002	MSD-0400-G-001
Design criteria	The Beluluane Hazardous Waste Facility	July 2002	MDD 0455-G-001
Technical report	Report on the geotechnical investigations carried out for the proposed Beluluane Hazardous waste facility in Mozambique	September 2002	MRF 0455-C-001
Specification	Beluluane Hazardous Waste Facility Operating Plan	September 2002	MST 0455-C-010
Specification	Project General	September 2001	BSS-0000-G-001
Specification	HVAC & Ventilation to Waste Disposal Office Building	July 2002	MST 0455-M-701
Specification	Underdrains and no-fines drains	October 2000	BSS 0000-C-010
Specification	Buildings for hazardous waste facility	April 2002	MST 0455-C-008
Specification	Pavement layerworks and surfacing for the Beluluane Hazardous Waste Facility Access Roads (Emulsion stabilised sand option)	July 2002	MST 0455-C-C003
Specification	Heating Ventilation and Airconditioning	December 2001	BSS-0000-M-019

Specification	Pavement layerworks and surfacing for the Beluluane Hazardous Waste Facility Access Roads (Gravel option)	July 2002	MST 0455-C-004
Specification	Additional geotechnical investigation at the Beluluane Hazardous Waste facility	August 2002	MST 0455-C-005
Specification	Bulk earthworks and liner construction	August 2002	MST 0455-C-002
Specification	Corrosion protection	November 2001	BSS-0000-G-003
Specification	Fabrication and erection of structural steelwork	May 2001	BSS 0000-S-001
Specification	Concrete construction	May 2002	BSS 0000-C-006
Specification	Roof and side cladding site wide	December 2001	BSS 0000-S-002
Specification	Medium pressure pipelines	June 2002	BSS 0000-C-019
Specification	Concrete	May 2002	BSS 0000-C-007
Specification	Earthworks to foundations and buildings	October 2000	BSS 0000-C-005
Specification	Underground gravity pipelines, cable ducts and sleeves	January 2002	BSS 0000-C-017

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Reports and specification relating to the projects

Document	Title	Date	Number

x 1997 Partial plan for Territorial Organization

x Report Geotechnical Investigation for proposed Beluluane by Gavrod Ball

ANNEXURE 1 : PAPER BY LEVIN AND VERHAGEN (2000)

A UNIQUE APPROACH TO EVALUATE THE UTILITY OF LANDFILL MONITORING BOREHOLES

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ABSTRACT: Environmental tritium ^{3}H is a very useful tracer of water and widely used in hydrological studies. This paper concentrates specifically on the use of tritium as a tracer to establish the hydrodynamics of boreholes as well as for tracing leachate movement. Rain water contains environmental tritium at concentrations of about 5 TU. Tritium has been used to establish the recharge to boreholes. Low or zero tritium level in ground water would indicate slow or no recharge while at the other end of the scale 5 TU would indicate recent or ongoing recharge by rainwater. Monitoring boreholes with low or zero tritium indicate very slow ground water movement and would therefore not be able to reflect pollution presently emanating from a landfill site or a leaking leachate containment pond. Anomalously high levels of artificial tritium have been discovered in leachates from landfill sites in the Republic of South Africa and elsewhere and indications are that this may be ubiquitous in such sites. The materials from which the tritium originates has not yet been established firmly. Whatever the source material, this artificial tritium in the leachate is a unique tracer. When the pre-pollution background values for recently recharged rainwater are established we can utilise the contrast to detect leachate leakage. With measured contrasts of up to 4 orders of magnitude this tracer is sensitive for picking up spillages or leakages. The origin of the tracer is unique (the leachate) and is indisputable. Environmental tritium can therefore be used to evaluate the usefulness of the monitoring boreholes and the artificial tritium in the leachate can detect movement from the leachate system to the monitoring boreholes

1. INTRODUCTION

Solid waste landfill designs are normally based on geotechnical and geohydrological information collected during site suitability investigations. These investigations are conducted according to the guidelines (Minimum Requirements, 1998) laid down by the Department of Water Affairs and Forestry for waste disposal by landfill. According to this document "a mandatory physical separation between the waste and the surface and ground water regimes, as well as an effective surface water diversion drainage system, are fundamental to all landfill designs".

Should the hydraulic properties of the underlying material be such that it cannot adequately retard the leachate after compaction or treatment, then the regulatory authority may prescribe the importation and

use of suitable material for lining and/or geotextile to ensure the required physical separation.

The integrity of the leachate collection and separation system is monitored by a monitoring borehole network designed and installed during the investigative or construction period of the site. The main objective of installing a monitoring borehole is to intersect ground water moving away from a waste management facility. Base line data is obtained from the monitoring borehole(s) before commissioning of the site. The monitoring boreholes are sampled at a certain frequency to detect any change in ground water quality which could be due to leakage of the system. The suitability of a monitoring borehole to detect leakage cannot always be ensured by geophysical and/or geohydrological investigations.

This paper discuss an approach using tritium, a radioactive isotope of hydrogen to evaluate the suitability of the monitoring borehole as well as unambiguously to identify leakage of the leachate containment system.

2. WHAT IS TRITIUM?

Environmental tritium is a very useful tracer of water and widely used in hydrological studies (IAEA 1983, Verhagen et al. 1991). Tritium is produced in nature by cosmic ray interaction with the upper atmosphere, and readily oxidised to water in which it is a conservative tracer as it is part of the water molecule. Depending on geographical location, rain water contains natural tritium at concentrations of up to some 5 TU (1 TU = $[^3H]/[^1H] = 10^{-18}$). Tritium is radioactive and decays through low-energy beta ray emission with a half-life of 12.43 years. Its radioactivity can only be measured in the laboratory. Minimum detectable values are about 5 TU by direct (screening) counting; following isotope enrichment, 0.2 TU can routinely be attained. The useful range of measurement of environmental tritium in geohydrological applications spans four to five half-lives and it is therefore measurable only in, and can act as an indicator or, recently recharged ground water.

Thermonuclear weapons testing in the latter 50's and early 60's increased tritium concentrations in rainfall by up to three orders of magnitude in the northern hemisphere and about one order in the southern hemisphere. This tritium "pulse" could be traced through hydrological systems such as ground water. At present, the widespread use of artificial tritium in e.g. Europe maintains tritium in rainfall at about one order of magnitude above the natural value. In Southern Africa, where the use of artificial tritium is much less common, tritium in rainfall has returned to close to natural values. Ground water usually has lower values, depending on residence times or recharge rates. Any water labelled with artificial tritium can therefore readily be detected and traced in the Southern African environment.

3. TRITIUM IN GROUND WATER

The presence of tritium in ground water in amounts similar to that in present day rainfall of the area, would be an indication of rapid and active percolation. Provided it is well protected against direct inflow from surface a borehole yielding water with present day rainfall values of tritium can therefore be considered an excellent monitoring borehole. It would rapidly respond to leakages and spillages of leachate which might already be visible after the first rainfall following the incident. Such boreholes should be sampled at about two or three monthly intervals.

Low but measurable tritium in ground water points to longer residence times for ground water, due to the delay in the unsaturated zone or low recharge/storage ratio in the unsaturated zone. Monitoring boreholes displaying such values may for a number of years show very little change. However, once pollution is detected in such a borehole it is certain that, even if the source is stopped, the levels of pollution will be

maintained for a number of years until it dissipates. Such boreholes are not considered good monitoring boreholes and frequent sampling is not recommended. A six monthly or annual sampling frequency is recommended depending on the measured base line tritium level.

The absence of tritium in ground water sampled from a monitoring borehole indicates very low recharge and ground water residence times well in excess of 50 years. Such boreholes cannot be considered good for early detection pollution monitoring and frequent sampling would be meaningless.

As tritium labels the water molecule itself, its concentration in e.g. ground water is, to a good approximation unaffected by processes in the sub-surface. It is therefore a conservative tracer. Sampling and handling water for tritium analysis is straightforward and requires no special precautions as compared to e.g. sampling for chemistry or dissolved gases. For direct counting a 50 ml sample suffices. For low level detection following isotope enrichment, a litre of water sample is usually required.

4. TRITIUM IN LANDFILLS

Levels of artificial tritium well above the usual environmental levels have been detected in association with landfill sites in the Republic of South Africa during a Water Research Commission project in Bloemfontein and Johannesburg (Verhagen et al. 1995). In a polluted borehole at the Bloemfontein North site a tritium level of 26.5 TU was measured. Other boreholes gave values

Table 1: Results of the Tritium in leachate measurements in the recent study

Site No	Province	Classification	Waste Source	Tritium (TU)
1	Kwazulu-Natal	G closed	Domestic high income	1787±14
2	Kwazulu-Natal	G closed	Domestic high income	425±6
3	Kwazulu-Natal	G closed	Domestic/industrial	65,2±0,4
4	Kwazulu-Natal	H	Industrial hazardous	98288±148
5	Kwazulu-Natal	G	Domestic lower income	3064±19
6	Kwazulu-Natal	G	Domestic/industrial	2144±12
7	Western Cape	G	Domestic mixed	191±5
8	Gauteng	G	Domestic industrial	2605±17
9	Gauteng	G closed	Mixed	75±3
10	Gauteng	G	Domestic high income	607±13
11	Gauteng	G	Domestic high income	6,3±0,6
12	Gauteng	G	Domestic/industrial	10,0±2,6
13	Gauteng	G	Domestic/industrial	1771±11
14	Gauteng	G	Domestic/lower income	104±4
15	Gauteng	G	Domestic mixed	16±3
16	Gauteng	G	Domestic/industrial	89±4
17	Gauteng	G	Domestic/industrial	48±3
18	Gauteng	G	Domestic/lower income	2569±9
19	Gauteng	H	Industrial hazardous	448±12

significantly above the expected maximum environmental level. In a borehole on the Bloemfontein South site a value of 28.1 TU was measured. Seven months later this value had increased to 40.1 TU. In both cases, significant amounts of leachate must clearly have entered the aquifer/borehole. At the time the source material in these landfills was thought to be associated with medical research.

During the same project, values up to 23,2 TU were found in the culvert water draining from the Waterval landfill in Johannesburg. As in the other sites, the reason for the elevated tritium values is not fully understood at present; the more so as this landfill had been closed for some 20 years.

During 1997 a total of 19 samples of leachate for tritium analysis was collected in a survey from landfill sites in Kwazulu Natal, Gauteng and Western Cape Province (Verhagen et al. 1998, Fourie et al. 1998). The locations of the sites are indicated on the map of South Africa in Figure 1. Using the direct counting technique, it was possible to screen samples with high tritium content from those with low and background values.

The values for the various sites are shown in Table 1and the values vary between just above background at 6,3 TU to 98288 TU. The samples are categorised according to province, with 6 from Kwazulu Natal, one from the Western Cape and 12 from Gauteng. Only two H class sites were sampled; the rest are all G class sites.

The results presented in Table 2 highlight two important points:

- The tritium value for the total leachate is highly variable and can be influenced by rainfall, slumping in the waste etc.
- There are large differences in tritium concentration at different points in the site. Tritium source(s) may therefore be highly localised within the body of the fill.

Table 2. Detailed leachate samples from site 4 November 1997

Sample	Tritium (TU)
Total leachate	5800±42
Leachate south	405±7
Leachate centre	405±7
Leachate north	12829±38

5. TRITIUM AS A TRACER OF LEACHATE

Simultaneous with these discoveries in South Africa, rather high levels of artificial tritium were reported in leachate from English landfill sites (Robinson & Gronow 1995). The potential of these tritium levels for tracing pollutants in water was soon recognised. However, the nature of the source materials of tritium in landfill sites are at present still open to conjecture. Artificial tritium synthetised into organic molecules is used as a tracer in medical research and diagnostics. The concentration of tritium in such compounds, although generally low in terms of biological radiation hazard, is many orders of magnitude higher than ambient levels in surface water and ground water. Even where the tracer materials themselves are conscientiously disposed of, associated contaminated materials might find their way onto landfill sites. Artificial tritium at considerably higher concentrations is used as an energy source with phosphorescent material in luminous signs and dials (Robinson & Gronow 1995). When such items are discarded and damaged, the tritium they contain can readily exchange with hydrogen-containing compounds and moisture in the landfill matrix, and the leachate which gravitates out of it.

As the use of tritiated material and items is assumed to be fairly limited in the southern African environment at present, it follows

that the distribution of tritium-containing materials, both geographically in different sites and within individual landfill sites, is likely to be patchy. The method of detection in the leachate is extremely sensitive. Tritium from a single item within a landfill could therefore produce significant levels in the total leachate output.

Monitoring boreholes evaluated as tapping actively recharged ground water, which show an increase in tritium above the baseline values during routine monitoring, should be regarded as giving an early warning of pollution. Resampling and further periodic sampling will confirm tritium levels above the base values obtained before site commissioning.

6. DISCUSSION

Evaluation of pollution at a number of South African sites (Verhagen et. al. 1998) showed that chemistry and chemical changes are not sensitive enough to confirm pollution in the monitoring system (Levin 1997). This is especially true where the background salinity of the ground water chemistry is high or where ground water movement is through clay with high ion exchange and absorption capacities for heavy metals, radionuclides or macro ions. As stated previously, (artificial) tritium is almost unique to landfill, and a near-perfect tracer, in that it does not participate in chemical reactions, is only slightly exchanged onto geological material and is easy to sample for.

In the case of the coastal sites the contrast between environmental tritium (a few TU) in ground water and leachate (up to 10^5 TU) is several orders of magnitude. The chloride content of the ground water in these coastal areas is typically about 10^2 mg/l and in the leachate some 10^3 mg/l, a contrast of only one order of magnitude. The chloride content of water for instance need not be derived from the leachate but from sources external to the landfill. Furthermore the tritium is uniquely derived from the waste and identifies the leachate in the presence of pollutants from other sources. Tritium in landfill leachates and the high contrast this presents with existing environmental levels at many landfill sites, makes this tracer most promising in studying leachate dispersal into the environment.

In the absence of known contamination, boreholes with a tritium signal close to values in present day rainfall will be excellent monitoring boreholes. These boreholes should respond to any leakage and should be monitored frequently. Boreholes with low but measurable tritium indicate slow movement of water especially through the unsaturated zone. Such boreholes need only to be sampled 6 monthly or annually. Once pollution has been observed, one can expect it to dissipate slowly over a long period after remediation of the leak. At the lower end of the scale are boreholes with near-zero tritium indicating very low recharge and groundwater residence times well in excess of 50 years. Such boreholes cannot be considered monitoring boreholes.

After commissioning of a waste site any change in the tritium content should be carefully monitored to establish any trend. Only boreholes monitoring actively recharged ground water will respond rapidly to leakage. Monitoring boreholes indicating lower recharge will show a delayed response.

7. CONCLUSIONS

Leakage from the leachate containment systems is monitored by boreholes located at localities where they can intersect movement of water away from the site. The dynamics of these boreholes can be evaluated by environmental tritium before commissioning of the site. Changes in tritium after the site is commissioned can uniquely be linked to leakage from the site.

From only a limited number of landfills investigated thus far, it can be concluded that artificial tritium levels useful for leachate tracing are to be found in the majority of landfill sites in South Africa. The sources of this artificial tritium in waste are still open to conjecture. A more detailed study of one site shows that such sources may be highly localised within the fill. The contrast between the levels of tritium in waste and in the natural surroundings found in this study gives it tremendous potential to be used as an environmental tracer of pollution or leakage at other landfill sites.

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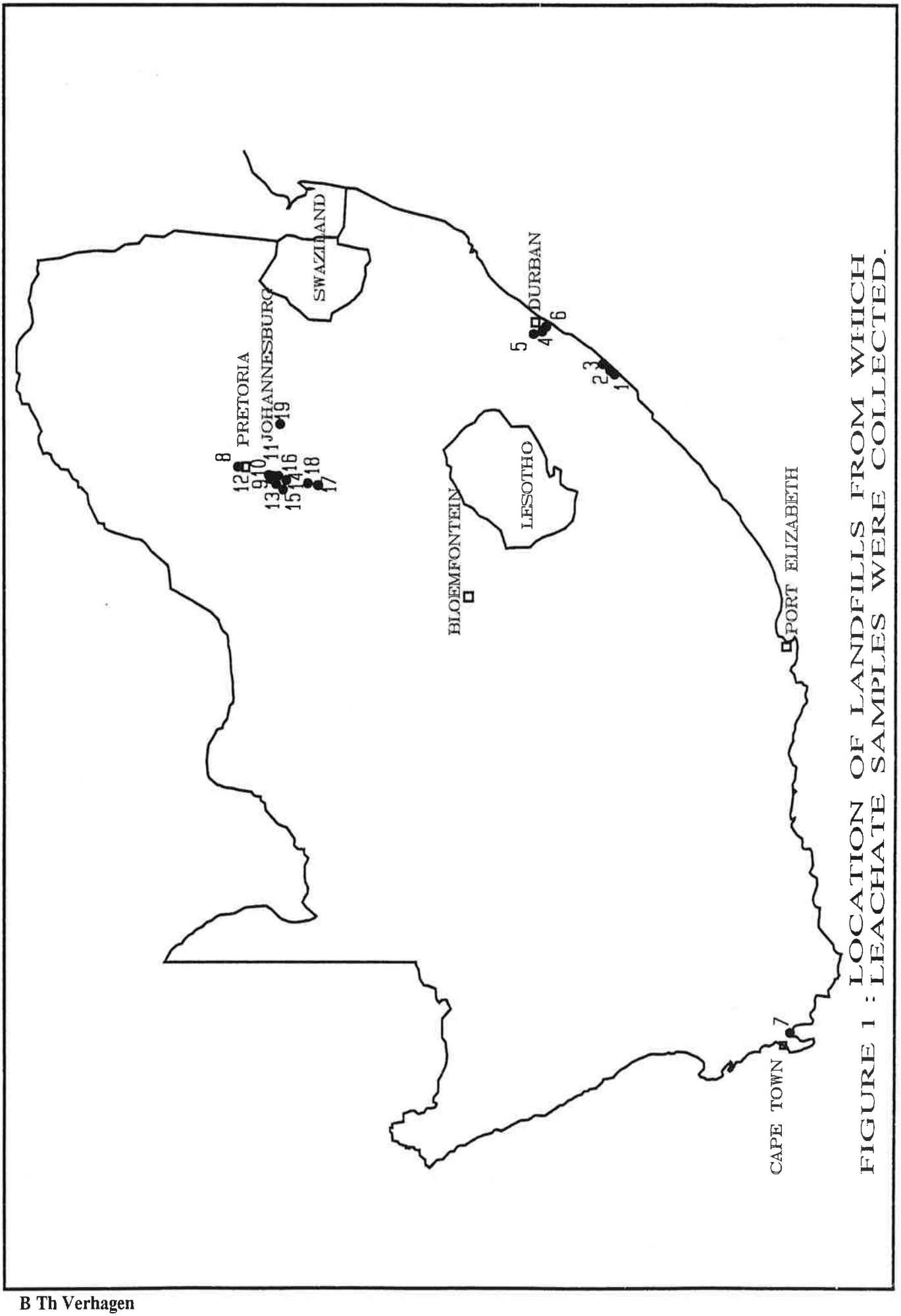

FIGURE 1 : LOCATION OF LANDFILLS FROM WHICH LEACHATE SAMPLES WERE COLLECTED.

ANNEXURE 2 : STABLE ISOTOPES

Oxygen -18 (^{18}O) and Deuterium (^{2}H)

Oxygen -18 (^{18}O) together with deuterium (^{2}H) are present in water in isotopic abundances of about $^{18}O/^{16}O$ = 0.2% and $^{2}H/^{1}H$ = 0.015% where ^{16}O and ^{1}H are the common, lighter isotopes. In various combinations, these isotopes constitute water molecules, principally of masses 18, 19 and 20. In phase processes such as evaporation and condensation, the different vapor pressures of these molecules cause small changes in the isotopic abundances, the heavier isotopes tending to concentrate in the denser phase. These small changes are expressed as a fractional deviation d from a standard called SMOW (standard mean ocean water), defined as:

$$d = [(Rs/Rr) - 1] \times 1000$$

Where Rs and Rr are the ratios of the abundances of the rare (heavier) isotope to the more abundant (light) isotope for the sample and reference standard, respectively.

Physical processes such as evaporation at the land surface can change the d values in the original precipitation, which therefore become diagnostic of water from different origins.

CONSTRUCTION, OPERATIONAL AND REHABILITATION ENVIRONMENTAL MANAGEMENT PLAN

FOR THE

MAVOCO HAZARDOUS WASTE HANDLING FACILITY, BELULUANE, MOZAMBIQUE

First Draft

October 2002

Prepared for
MICOA

By
AFRICON Environmental Services

CONSTRUCTION, OPERATIONAL AND REHABILITATION ENVIRONMENTAL MANAGEMENT PLAN (EMP) FOR THE MAVOCO HAZARDOUS WASTE HANDLING FACILITY, BELULUANE, MOZAMBIQUE

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FOR:

MICOA
As part of the Environmental Impact Assessment

CONTENTS

Section i Abbreviations

BATNEEC	Best Available Technology Not Entailing Excessive Cost
BPEO	Best Practicable Environmental Option
BS	British Standard
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EICR	Environment Impact Control Report
EMP	Environmental Management Plan
EO	Environmental Officer
FML	Flexible Membrane Liner
GCL	Geomembrane Clay Liner
H	Hazardous Waste or Landfill for Hazardous Waste
H:H	Hazardous Waste Landfill that can receive wastes with a hazard rating of 1 and 2
IAP	Interest and Affected Parties
IEM	Integrated Environmental Management
ISO	International Organisation for Standardisation
ISO	International Organisation for Standardisation
MICOA	Ministerio Para a Coordenacao da Accao Ambiental
PI	Plasticity Index
PPM	Parts Per Million
RE	Resident Engineer
SABS	South African Bureau of Standards
SADC	Southern African Development Community
WWTW	Waste Water Treatment Works

Section ii Glossary and Terminology

Analysis	:	An investigation to ascertain the constituents of a waste.
Area Method of Landfilling	:	The method whereby non-putrescible waste is spread in layers not exceeding 0,5m in thickness. This method is usually applied to hazardous landfill site operation.
Basel Convention	:	Mozambique became a signatory to the Basel Convention in 1994. The Convention controls the transboundary movement of hazardous wastes and their disposal.
BPEO	:	Best Practicable Environmental Option. BPEO is the outcome of a systematic consultative and decision-making procedure that emphasises the protection of the environment across land, air and water. It establishes, for a given set of objectives, the option that provides the most benefit or least damage to the environment as a whole at acceptable cost in the long term and as well as the short term.
Carcinogens	:	A substance or agent producing or inciting cancer. These substances can be grouped as: Group A - Clinically and epidemiologically proven in humans, Group B - Proven without doubt in laboratory animals, Group C - limited evidence in animals, Group D - Inadequate and doubtful data.
Closure	:	The act of terminating the operation of a landfill. Closure is preceded by rehabilitation, and followed by end-use and post-closure monitoring.
Co-Disposal (General Waste with Hazardous Waste)	:	The mixing and joint disposal of Hazardous (H) and General (G) waste in the same landfill. The co-disposal of General Waste with Hazardous Waste as a means of facilitating disposal on an H site is acceptable, whereas the co-disposal of any significant quantity of Hazardous Waste with General Waste on a General Waste disposal site is unacceptable.
Co-Disposal (liquid with Dry waste)	:	The mixing of high moisture content or liquid waste with dry waste. This affects the water balance and is an acceptable practice on a Hazardous Waste site, but is only acceptable on a General Waste site equipped with leachate management measures.
Compaction	:	The compaction of waste achieved by using purpose built approved plant (the unit of measurement is kilogram mass per cubic metre kg/m3.)
Contaminate	:	The addition of foreign matter to a natural system. This does not necessarily result in pollution, unless the attenuation capacity of the natural system is exceeded.
Contractor	:	The natural or juristic person or partnership whose tender has been accepted by or on behalf of MICOA, and, where applicable, includes the Contractor's heirs, executors, administrators, trustees, judicial managers or liquidators, as the case may be, but not, except with the written consent of MICOA, any assignee of the Contractor.

Cover : The material used to cover and seal off putrescible or odour-causing waste. It is usually soil but may comprise builders' rubble, ash or other approved material.

Development Plan : The planned phased development of the landfill from the existing landform through the operation, which is usually divided into several phases, to the final completed landfill planned for the desired end use.

Duty of Care : This requires that any person who generates, transports, treats or disposes of waste must ensure that there is no unauthorised transfer or escape of waste from his control. Such a person must retain documentation describing both the waste and any related transactions. In this way, he retains responsibility for the waste generated or handled.

Effluent : A stream flowing from a larger stream, lake, sewerage tank, industrial process.

Encapsulation : The coating or enclosure of waste within an inert durable material. Micro-Encapsulation: the coating of individual particles of a waste. Macro-Encapsulation: the isolation of the wastes in sealed, reinforced concrete cells or capsules. The capsules are then located in a demarcated area of an H landfill site.

Engineered Cell : A cell that is lined so as to contain Hazardous Waste and prevent leachate from the waste escaping from the cell.

Environment : Associated cultural, social, soil, biotic, atmospheric, surface and ground water aspects associated with the landfill that are, or could potentially be, impacted upon by the landfill.

Environmental Impact Assessment (EIA) : An investigation to determine the potential detrimental or beneficial impact on the surrounding communities, *fauna*, *flora*, water, soil and air arising from the development or presence of a waste disposal site.

Flammable Liquids : Liquids which give off a flammable vapour at or below 61*0*C using the closed cup test.

Flammable Solids : Substances, other than those classed as explosives, which are readily combustible or may cause or contribute to fires.

General Waste : Waste that does not pose an immediate threat to man or to the environment, i.e., household waste, builders' rubble, garden waste, dry industrial and commercial waste. It may, however, with decomposition, infiltration and percolation, produce leachate with an unacceptable pollution potential. (See Waste.)

Hazard Rating : A system for classifying and ranking Hazardous waste according to the degree of hazard they present. This is based on Mammalian Acute and Chronic Toxicity, Ecotoxicity, and Environmental Fate. Based on this, Hazardous waste is classified as: Extreme Hazard, Hazard Rating 1; High Hazard, Hazard Rating 2; Moderate Hazard, Hazard Rating 3; and Low Hazard, Hazard Rating 4.

Hazardous Waste (alternative definition) : Waste that may, by circumstances of use, quantity, concentration or inherent physical, chemical or infectious characteristics, cause ill-health or increase mortality in humans, *fauna* and *flora*, or adversely affect the environment when improperly treated,

		stored, transported or disposed of. (See Waste.)
Hazardous Waste	:	Waste, other than radioactive waste, which is legally defined as Hazardous in the state in which it is generated, transported or disposed of. The definition is based on the chemical reactivity or toxic, explosive, corrosive or other characteristics which cause, or are likely to cause, danger to health or to the environment, whether alone or when in contact with other waste. *After UNEP definition.* (See Waste.)
Hazardous Waste Landfill (H:H)	:	A containment landfill, designed specifically for the disposal or codisposal of Hazardous Waste.
Interested and Affected Parties (IAP's)	:	Interested and Affected Parties are those people who will be affected in some way by the Hazardous Waste disposal process. They may be represented by residents or farmers, a whole residential community, or the public at large.
Landfill (n)	:	The waste body created by landfilling. This may be above or below grade, or both.
Landfill (v)	:	To dispose of waste on land, whether by use of waste to fill in excavations or by creation of a landform above grade, where the term "fill" is used in the engineering sense.
Leachate	:	An aqueous solution with a high pollution potential, arising when water is permitted to percolate through decomposing waste. It contains final and intermediate products of decomposition, various solutes and waste residues.
Leachate Management	:	The collection and drainage of leachate to a point where it can be extracted for treatment. This requires a system of under-drains and liners and, in certain instances, is synonymous with containment.
Liner	:	A layer of low permeability placed beneath a landfill and designed to direct leachate to a collection drain or sump, or to contain leachate. It may comprise natural materials, synthetic materials, or a combination thereof. (See also FML and Geomembrane.)
Medical Waste	:	Waste generated from such places as hospitals, clinics, doctors' rooms, laboratories, pharmacies, and research facilities.
Operation	:	All the work to be performed in accordance with the Operating Plan.
Operation Plan	:	The way in which the landfill is actually operated, commencing at the level and detail of daily deposition, spreading, etc. (micro) and continuing to the development and rehabilitation sequence, access, drainage, etc., within a given phase of the development plan (macro).
Precautionary Principle	:	Where a risk is unknown; the assumption of the worst case situation and the making of provision for such a situation.
Responsible Person	:	A person(s) who takes professional responsibility for ensuring that all or some of the facets of the handling and disposal of Hazardous Waste are properly directed, guided and executed, in a professionally justifiable manner.
Sanitary Landfill	:	Describes a method of disposing of refuse on land without causing nuisances or hazards to public health or safety, by utilising the principles of engineering to confine the refuse to the

		smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth or inert material at the conclusion of each day's operations, or at such more frequent intervals as may be necessary in order to adequately seal the deposited waste.
Sanitary Landfill	:	Describes a method of disposing of refuse on land without causing nuisances or hazards to public health or safety, by utilising the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth or inert material at the conclusion of each day's operations, or at such more frequent intervals as may be necessary in order to adequately seal the deposited waste.
Site	:	Means the land including the existing services and waste disposal site known as the Beluluane Hazardous waste facility landfill site provided by MICOA for the purposes of the execution of the Operating Plan.
Solidification	:	Solidification or cementation is a process in which the waste is converted to an insoluble rock-like material by mixing with suitable materials.
Transporter	:	A person, organisation, industry or enterprise engaged in or offering to engage in the transportation of waste.
Treatment	:	Treatment is used to remove, separate, concentrate or recover a hazardous or toxic component of a waste or to destroy or, at least, to reduce its toxicity in order to minimise its impact on the environment.
Waste	:	An undesirable or superfluous by-product, emission, or residue of any process or activity which has been discarded, accumulated or stored for the purpose of discarding or processing. It may be gaseous, liquid or solid or any combination thereof and may originate from a residential, commercial or industrial area. This definition excludes industrial waste water, sewage, radioactive substances, mining, metallurgical and power generation waste.
Waste Disposal (v)	:	The act of disposing of waste.
Waste Disposal Site	:	Any place at which more than 100 kg of a Hazardous Waste is stored for more than 90 days or a place at which a dedicated incinerator is located is termed a Waste Disposal Site.
Waste Stream	:	A continuous flow of waste from an industry, activity, process or group.
Working Face	:	The active part of the landfill where waste is deposited by in coming vehicles, then spread and compacted on the working level by a landfill compactor or bulldozer.

Section 1 Introduction and Project Brief

Micoa is committed to the effective and environmental sensitive construction, operation and rehabilitation of the Mavoco Hazardous Waste Handling Facility in Beluluane, Mozambique. This Environmental Management Plan (EMP) reflects the emphasis placed on high environmental standards for the life span of the facility.

The main objectives of environmental management during all project life-cycle phases from construction to decommissioning, rehabilitation and long term monitoring are to control or manage potentially significant impacts of the activity on the receiving natural environment, and to contain or mitigate actual impacts. It also provides for monitoring and auditing of the implementation of the EMP and will provide feedback to the management of the facility on the environmental performance and opportunities for improvement of the systems in place.

Section 2 Approach and Methodology

The approach is to consider the operational and management component of the environment in its totality. This approach considers environmental aspects in a typical 'cradle to grave' approach, focusing on the complete project life cycle. The system is structured in such a way that it could easily be incorporated into an ISO14001 compliant Environmental Management System (EMS), should this be required.

The methodology for the compilation and implementation of the EMP is divided into four overarching steps:-

- Establishment of impacts and cause effects of construction, operations and decommissioning & rehabilitation as well as long term monitoring activities from the Environmental Impact Assessment (EIA),
- Establishment of applicable standards and norms,
- Completion of EMP documentation to mitigate all potential impacts within the applicable standards and norms, and
- Implementation monitoring and compliance auditing.

This EMP meets the requirements to ensure long-term sustainability of the project in meeting the environmental responsibilities associated with the handling and landfilling of hazardous wastes. The document is split up into 3 main sections, applicable to the 3 different phases of EMP implementation:

Section 3A: Construction Phase of the Access Road and Facility
Section 3B: Operational Phase of the Facility
Section 3C: Decommissioning and Rehabilitation Phase of the Facility

Section 3 Environmental Management Plan

The EMP document is split up into 3 main sections, applicable to the 3 different phases of EMP implementation:

Section 3A: Construction Phase of the Access Road and Facility
Section 3B: Operational Phase of the Facility
Section 3C: Decommissioning and Rehabilitation Phase of the Facility

Each of these sections has its own table of contents.

SECTION 3A : CONSTRUCTION PHASE OF ACCESS ROAD AND FACILITY

SECTION 3A
CONSTRUCTION PHASE OF ACCESS ROAD AND FACILITY

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Section 3A-1 Introduction

This section of the EMP should be read with the construction and design specifications. It focuses on the significant issues to be addressed and mitigated during the construction phase and specifies monitoring and auditing criteria for this phase.

Section 3A-2 Establishing Statutory and Legal Requirements

An Environmental Impact Assessment (EIA) was done for the development of the facility and the access road. As part of the fulfilment of the EIA requirements of MICOA, an Environmental Management Plan (EMP) has to be prepared for the construction of the facility.

This EMP aims to ensure compliance to the Mozambican Statute No 48/73: Occupational Health and Safety in Industrial Premises and the Mozambican Labour Law of 20 July 1998, as well as the South African Occupational Health and Safety Act (Act No 85 of 1993) on the construction site, in so far as protecting the environment.

Section 3A-3 Applicable Standards and Management Criteria

The standards and management criteria applicable to this phase of the project include water quality standards for both potable water supply and effluent discharge from the site, air quality standards and noise standards. Due to the lack of local standards and the sensitivity associated with the handling and disposal of hazardous waste, accepted regional SADC standards, like the South African SABS standards will be referenced.

3A-3.1 Water Quality Standards: Potable Water and Effluent Discharge

The acceptable levels of water quality parameters are given below. Testing will be performed either by an International Organisation for Standardisation (ISO) 9000 accredited laboratory or by an on-site laboratory, which will entail the acquisition of testing equipment. All test equipment will be calibrated every six months and records of calibration will be kept by the relevant laboratory.

The two columns on the right of the table indicate the applicable standards which will be met for potable water usage and for wastewater release into the environment. A shaded cell indicates that the specific element will be tested for.

It must be borne in mind that this list of contaminants is by no means exhaustive. In the event of any spillage of suspected hazardous nature, the MICOA will be consulted to determine whether a more substantial list of contaminants should be tested for, based on the nature and extent of the spill.

Effluent samples will be taken according to the procedures of SABS 241.

Variable	Unit	Limit	Potable Water	Waste Water
Colour, Odour, Taste	-	Not discernible		
PH	-	6-9		
Dissolved Oxygen	saturation	80%-120%		
Total coliforms	Counts/100ml	0-5		
Faecal coliforms	Counts/100ml	0		
Temperature change from natural water temp(point f)	°C	≤2		
COD	mg/l	75		
BOD	mg/l	10		
Total Suspended Solids	mg/l	25		
Aluminium	mg/l	≤0.005		
Ammonia	mg/l	≤0.007		
Arsenic	mg/l	≤0.01		
Asbestos	fibres/l	$\leq 1x10^6$		
Free available chlorine	mg/l	0.3-0.6		
Calcium	mg/l	16-32		
Chloride	mg/l	0-100		
Chromium(VI)	mg/l	≤0.007		
Chromium(VI)	mg/l	≤0.012		
Copper	mg/l	≤0.0003		
Cyanide	mg HCN/l	≤0.001		

Variable	Unit	Limit	Potable Water	Waste Water
Electric Conductivity	MS/m	≤70		
Endosulfan	µg/l	≤0.01		
Fluoride	mg/l	≤0.75		
Iron	mg/l	≤0.1		
Lead	mg/l	≤0.0002		
Manganese	mg/l	≤0.05		
Mercury	mg/l	≤0.001		
Nitrate	mg/l	≤6		
Nitrogen(N) (Inorganic)	mg/l	≤0.5		
Phenol	mg/l	≤1		
Phosphorous(P) (Inorganic)	N:P ratio	≤25-40:1		
Selenium	mg/l	≤0.002		
Sodium Content	mg/l	0-100		
Sulphates	mg/l	≤200		
Total Dissolved Solids	mg/l	≤450		
Turbidity	NTU	≤1		
Zinc	mg/l	≤0.002		

3A-3.2 Air Quality Standards

The likelihood of unacceptably high air pollution during the construction phase, apart from dust nuisance, is low. Only Total Suspended Solids, Smoke and Dust Fallout will be measured during this phase. Other pollutants will be measured when an obvious nuisance occurs, for the purposes of prosecution or mitigatory action, as directed by MICOA. Air Quality testing will be performed by an ISO 9000 accredited laboratory.

Applicable standards for the measurement of total suspended solids, smoke and dust fallout are:-

Total Suspended Solids:	24 hr average – 300 microgram/m^3
Smoke:	24 hr average – 250 microgram/m^3
Dust fallout (Deposition):	Slight – less than 0.25 g/m^2/day
	Moderate – 0.25-0.5 g/m^2/day
	Heavy – 0.5-1.2 g/m^2/day
	Very heavy – more than 1.2 g/m^2/day

The 24 hr limits are not to be exceeded more than 3 times per year.

3A-3.3 Noise Standards

The various applicable standards pertaining to the construction activities expected at the facility and access road include the following list:-

- SABS ARP 020:1992 – Sound Impact Investigations on Integrated Environmental Management
- SABS 0210:1996 – Calculating and Predicting Road Traffic
- SABS 0103:1994 – The Measurement and Rating of Environmental Noise with respect to Annoyance and to Speech Communication
- BS 5228 –1 – Noise Control on Construction and Open Sites – Part 1: Code of Practice for Basic Information and Procedures for Noise control.

SABS 0103:1994, in particular, is useful in identifying acceptable noise performance levels. Table 6 of this standard stipulates various increments of sound level increase, and the concomitant subjective impact experienced by the community experiencing it. This table will thus be used as a guideline for requirements espoused by the construction site.

Noise monitoring will be done on the assumption that the vast majority of plant and machinery fall within the acceptable noise levels. Where gross transgressions of noise regulations and guidelines exist, measurement and punitive action will be taken. It will be most appropriate to enlist the services of an ISO 9000 accredited acoustics laboratory rather than incur the cost of permanent monitoring equipment.

The SABS Codes Of Practice SABS 0103:1994 *The measurement and rating of environmental noise with respect to annoyance and to speech communication*, gives guidance as to acceptable noise levels. SABS 0103:1994 uses the unit of dBA, which is the

unit of a running average of noise over a fairly short period, with prescribed guideline limits for this parameter. The predominantly rural environment around the proposed site would be affected to a greater degree than other settings by the same level of noise. The appropriate noise limits are listed for different environments. SABS 0103:1994 uses the method of identifying typical ambient noise levels at each specific location and then to stipulate noise increases of increasing irritation to the receiver.

Typical ambient noise rating level (dBA):-

District	Daytime	Evenings/weekends	Night time
Rural (outside)	45	40	35
Quiet suburban (outside)	50	45	40
Urban (outside)	55	50	45
Industrial (outside)	70	65	60

Table 6 from the SABS 0103:1994, categorising expected group or community responses, is given below:-

	Estimated community/group response	
Excess ΔL_r / dB	Category	Description
0	None	No observed reaction
>0 ≤ 5	Little	Sporadic complaints
>5 ≤ 10	Medium	Widespread complaints
>10 ≤ 15	Strong	Threats of community group action
>15	Very strong	Vigorous community group action

Section 3A-4 Overarching Environmental Objectives During Construction Phase

This section describes mitigation measures and is partly prescriptive, identifying specific people to undertake specific tasks, in order to ensure that impacts on the environment are minimised during the construction phase.

It is important to note that the EMP is a 'live' document and establish the local conditions and modus operandi, as they exist in Mozambique. The ECO will request environmental method statements from the contractor for specific sensitive or high-risk actions, at his discression. It is important to note that the EMP is regarded as a 'live' document that can be changed should more effective methods of mitigation be proposed and accepted by the ECO. MICOA will be updated on a monthly basis in this regard. All accepted method statements will be regarded as being part of the EMP documentation and are subject to all terms and conditions contained in the main EMP document. A method statement describes the scope of intended

work step-by-step detailing what, how, where and when an action will take place, as well as detail on the proposed mitigation measures to meet the EMP requirements. No work may commence prior to the approval of the method statement by the ECO.

Section 3A-5 Responsibilities of Environmental Control Officer (ECO) and External Auditor

This section highlights the responsibilities of the ECO and the external auditor in terms of the requirements of the EMP during this phase of the project.

3A-5.1 Environmental Control Officer

The Environmental Control Officer (ECO) will be appointed by MICOA to oversee the implementation of the construction EMP on site, and will have no contractual or other agreement with the contractor to ensure unbiased judgement. The ECO could be appointed full- or part-time, as required by MICOA. It is expected that a minimum of 2 site visits per week for the duration of the construction period is required for proper monitoring of implementation.

The ECO has the authority to stop the works per formal site instruction notification, if in his opinion there is a serious threat to or impact on the environment due to the construction operations, until such threat or impact has been mitigated successfully. In such cases the ECO must inform the RE and MICOA as soon as possible.

Upon failure by any employee of the contractor, including the site agent, to show adequate consideration to the environmental considerations as described in this EMP, the ECO may recommend that such employee be removed from site. No extension of time will be considered in case of such suspensions and all costs will be borne by the contractor.

The ECO will keep a site diary to record any significant incidents. This diary will be made available to the contractor, MICOA and the RE upon request. Records of the successful implementation or shortcomings of the implementation will be kept. The implementation status of the EMP will be a fixed agenda point for all contract site meetings and all outstanding EMP issues will be discussed and implementation actions with due dates recorded.

3A-5.2 External Environmental Auditor

The external environmental auditor will be appointed by MICOA to audit the ECO's records of implementation and success of mitigation measures adopted on site. It is expected that a minimum of one audit per 3 month-period for the duration of the construction period is required for proper auditing of the monitoring of implementation. The EMP will be criteria against which the ECO will be audited. The external auditor will prepare a short audit report after each audit for submission to MICOA.

Section 3A-6 Mitigation and Management Proposals for Significant Aspects

This section proposes mitigation and management measures for significant aspects during the early stages of establishment on site.

3A-6.1 Clearing and grubbing

3A-6.1.1 Cultural and historical features

Before commencement of the clearing of the terrain, the Contractor must familiarise himself with the type and location of any sites of cultural or historical importance enumerated in the EIA report but shall not limit himself to those mentioned. The elements ultimately to be affected can only be determined during construction.

The Contractor must then present the Environmental Control Officer (ECO) as well as the Resident Engineer (RE) with a layout of his works including road reserves, haul roads, borrow areas and construction camps and satisfy the ECO that the known elements mentioned in this study are either avoided altogether or, in the case of gravesites, will undergo translocation after thorough consultation with the affected communities.

Special features identified in the EIA report must be located and demarcated. Care must be taken to prevent accidental damage during the construction stage. Workers on site must be informed about the possible consequences of interfering with these elements.

3A-6.1.2 Gravesites

The issue of translocation of graves is an extremely sensitive one. There is a strict order of events, which must be adhered to:-

- The gravesite must be reported to the RE who will then forward the information to MICOA.
- The contractor must then negotiate with the family of the deceased to reach an agreement on exhumation and reburial.
- Once an agreement is reached, the exhumation and reburial must be performed in accordance with the applicable rituals. It will be the duty of the contractor to supply caskets, dig new graves and perform the exhumation and reburial upon request by the civil authority. This will be over and above the cost of the ordinary contract requirements.

It is recommended that all gravesites remain in situ, and are avoided.

3A-6.1.3 Property

Prior to construction, property to be affected would have been identified and the owners informed and compensated. However, there is a likelihood that previously undetected property will be encountered or that the construction of the road alignment may change to

conserve special features, in which case the property owners may not have been notified. In this case, the following procedure must be strictly adhered to.

- The property owner must be located and informed of the development, by a designated spokesperson. This spokesperson must be well versed with procedure in relocation and compensation as used by MICOA. This current procedure should prevail.
- The system of compensation must be explained and should there be any disagreement in this regard, a more senior representative of MICOA should be involved in further discussions.
- This method of negotiation must continue until an agreement is reached.

Although it is unlikely that a deadlock will be reached, it is vital that the property not be damaged or removed without the consent of the owner. This will cause irreparable damage to the relationship between the contractor and the local communities.

3A-6.1.4 Wetland areas along the proposed route

Construction activities must stay clear of wetland areas if possible. If it is inevitable that the road must traverse these areas, construction activities must make sure that the minimum siltation of the water body occur and that water flow continues. The construction footprint in these areas must be kept to the minimum with no disturbance outside the construction area. Sensitive wetland areas must be demarcated with white boulders if they are near the construction area to prevent damage and to ensure that no vehicular movement are allowed across these areas. These boulders must be removed at the end of construction. Erosion channels in wetland areas must be rehabilitated or prevented during the construction phase. The users of the wetland / springs impacted upon by the proposed construction activities must be identified. Community structures must be used in the process of negotiation to compensate for the loss of properties. Procedures used by MICOA for the compensation of loss of wetlands / loss of water supply must be taken into consideration.

3A-6.1.5 Dust suppression

The area cleared for construction will be sprayed with water regularly to suppress dust formation. Complaints regarding dust formation will be noted and recorded in the site diary by the ECO and appropriate action taken.

3A-6.2 Topsoil clearing, stockpiling and replacing

Topsoil shall be cleared of woody vegetation before ripping and removing. The topsoil is regarded as the top 150mm of the soil profile irrespective of the fertility appearance or physical depth. Topsoil is to be stripped when it is in as dry a condition as possible in order to prevent compaction. The topsoil, including the existing grass cover is to be shallowly ripped (only the depth of the topsoil) before removal. This is to ensure that organic plant material, and the natural seed base is included in the stripping process.

Soil stockpiles shall not be higher than 2.5m or stored for a period longer than one year. The slopes of soil stockpiles shall not be steeper than 1 vertical to 2.5 horizontal. No vehicles shall be allowed access onto the stockpiles after they have been placed. Stockpiles shall not

be allowed to become contaminated with oil, diesel, petrol, waste or any other material, which may inhibit the later growth of vegetation. The contractor shall apply soil conservation measures to the stockpiles to prevent erosion. This can include the use of erosion control fabric or grass seeding.

The contractor shall devise a soil conservation and stockpiling plan, to be approved by the ECO and RE, which shall detail:-

- Stockpile sizes, layout and form
- Means of erosion (wind and water) prevention for stockpiles
- The rehabilitation measures to be taken for the area occupied by the stockpile, should the ECO deem it necessary.
- A generic schedule of soil replacement for areas where work has been completed. Soil replacement should preferably run in parallel (where feasible) with the construction process.
- Soil erosion prevention measures for general site use
- Details of temporary or permanent soil stabilising and reinforcement works

Dust and erosion of topsoil from runoff must be minimised through appropriate watering and the avoidance of windy or excessively rainy conditions during transport and application. Stockpiled topsoil from the construction areas shall be used to rehabilitate the construction campsites and other areas disturbed during construction.

3A-6.3 Fauna and flora

Natural vegetation shall be kept in as undisturbed a state as possible. Special attention shall be paid to preserve large trees and plant communities such as wetlands, sponges, forest of any sort and riparian vegetation. Indigenous plants or wild animals (including reptiles, amphibians or birds etc.) may not be damaged or harmed, excluding vegetation removals as part of the development requirements. All incidents of harm to any animal or natural vegetation, apart from the agreed areas, must be reported to the ECO.

Local communities must be given the option of using any plants of medicinal value. Specimens must not, however, be given away for any other use e.g. firewood or structural purposes. The ECO will oversee the distribution of these plants. All remaining plants must be used in the rehabilitation phase and will be kept in a site nursery for this purpose.

The works shall be cleared of alien vegetation as identified by the ECO. Labour intensive methods shall be used as far as possible. Clearing of alien species should, as far a possible, be done during the months of the year in which the plant is not in seed. This will prevent inadvertent spreading of seed. An effort must be made to remove the entire root system where after the plant shall be left to dry out on a hard surface that will not facilitate the germination of seed.

3A-6.4 Establishment of construction camp

This section covers activities associated with the establishment of the construction camp an include fencing, camp positioning, construction and building platforms, buildings and temporary roads.

3A-6.4.1 Fencing

The purpose of fenced areas shall be to secure the contractor's equipment and to prevent unauthorised access and the interference of domestic or wild animals. Fencing at construction camps shall be suitably secured. No unauthorised pedestrian or vehicular access shall be allowed into fenced off-limits areas.

Fencing shall be kept neat at all times. The contractor shall be responsible for the maintenance of all fences. Breaches in the fencing must be repaired immediately.

All exclusion areas are strictly out of bounds. The clearing for permanent fencing shall be limited to the removal of shrubs within 1 m of the fence line. No grass cover and topsoil is to be removed within the fence alignment. Galvanised diamond mesh fencing, preferably with a matte coating, will be used.

3A-6.4.2 Construction Camp Positioning

The planning, positioning and design for the construction camp and quarry must ensure that there is a minimum impact on the environment. Where possible existing infrastructure and disturbed areas must be used. The placement of the construction camp and quarry, and compensation must be negotiated with the landowner. The construction camps must be placed away from villages in the surrounding area to ensure that the cultural heritage of the communities are not impacted upon by construction workers from different cultural backgrounds. Local labourers must be used as far as possible to minimise cultural intrusion of the communities in the area.

No fires may be allowed outside the construction area / construction camp and adequate fire fighting equipment according to the fire hazard during the construction period must be available on site. These will be in good working order. At least one all-purpose type 12.5 kg extinguisher will be provided at the construction camp. Welding, gas cutting or cutting of metal will only be permitted inside the working areas.

3A-6.4.3 Platforms for temporary site buildings and aggregate storage

The establishment of either platform must not contravene the specifications of Section 3A-6.1 Clearing and Grubbing above.

Concrete platforms shall be required for all site buildings including offices, storage buildings, vehicle wash-bay and vehicle housing sheds. Compacted earth platforms will be required for storage of aggregate. Settling ponds are to be provided to allow for temporary detention of drainage water from the construction camp prior to discharge into a natural watercourse.

Construction of the ponds shall take place prior to topsoil stripping or any other construction activity.

All screed slab and compacted sub-soil platforms will be removed from site on decommissioning of the structures.

3A-6.4.4 Erosion Protection

The Contractor shall take appropriate and active measures to prevent erosion resulting from his own works, operations and activities as well as storm water control measures to the satisfaction of the ECO and RE. Restoration costs are likely to be for the contractor's account, should these measures not be reasonably implemented. Aspects normally covered in construction contracts in terms of "protection of works" are standard and are not to be billed or confused with any details covered under environmental requirements. During construction the Contractor shall protect areas susceptible to erosion by installing all necessary temporary and permanent drainage works as soon as possible. Other measures as may be necessary shall be taken to prevent the surface water from being concentrated in the wetland, streams or dams and from scouring the slopes, banks or other areas. All such measures must be discussed with and approved by the ECO. Measures can include cut off trenches, straw stabilising, brush packing etc. A method statement is required from the Contractor prior to site clearing.

3A-6.4.5 Site buildings at construction camps

All buildings will be soundly built for the benefit of the personnel. The relevant safety codes pertaining to *inter alia* load, structure, lighting, noise are applicable here. Buildings should preferably be pre-fabricated or constructed of re-usable/recyclable materials. The structure and its alignment, must, as far as possible, reduce the need for air conditioning and artificial lighting but it must be ventilated properly. Buildings should be built of materials, and aligned in such a way as to minimise the visual impact. Temporary site building footprints are to be rehabilitated and revegetated, to the satisfaction of the ECO, when construction is complete.

3A-6.4.6 Temporary site roads

Topsoil shall be removed as described in Section 3A-6.1 Clearing and Grubbing, prior to the construction of any temporary road. No new site roads other than those detailed by the RE, as agreed upon in terms of the site layout plan, shall be developed by the contractor. All new site roads shall be approved by the RE and the ECO. All site roads shall be decommissioned by the contractor and rehabilitated using the stockpiled topsoil. All erosion damage shall be repaired as soon as possible to the satisfaction of the RE and the ECO. Displaced topsoil shall be replaced. Drainage discharge points will be protected by stone pitching until a point where the velocity of the runoff has been dissipated to such an extent that no erosion will occur.

3A-6.5 Storage of construction materials

This section covers the storage of construction materials, including aggregates and layerworks materials, cement, fuels and lubricants for vehicles, plant and equipment.

3A-6.5.1 Storage of aggregates and fill and layerworks material

Fine aggregate shall be stored on a compacted earth platform. The contractor shall ensure so that no excessive amount of fine aggregate is washed from the storage area onto the rest of the site with the use of barriers designed to the satisfaction of the RE.

Coarse aggregate shall be stored, as a minimum, on a surface of compacted inert sub-base material. Run-off from the stockpile shall be diverted to an evaporation pond where fines will be allowed to settle out.

The stockpiled area is to be revegetated upon removal of stockpiled material. Clearly defined borders for the stockpiling of material shall be stipulated by the RE and the contractor shall contain stockpile within these boundaries. Fine material shall be covered with tarpaulins in strong winds as instructed by the RE and ECO.

3A-6.5.2 Storage of cement

Cement shall be delivered in sound and properly secured bags or in approved bulk containers. Cement products in sacks shall be stored in an enclosed storage area underlain by a concrete platform with the bags themselves raised off the ground with the use of pallets. The storage facility and surrounding area shall be swept and cleaned regularly as required to ensure that cement products do not enter the surrounding environment. Where concrete batching is done, the ground cover surrounding the silo and dispatch area is to be a concrete slab. This will ensure that any cement spilt is easy to remove.

3A-6.5.3 Storage of fuels and lubricants

All aboveground petroleum product (diesel, oil and petrol) storage tanks should have a concrete platform. In the event of a spill, pumping of the product, either for recovery or for disposal must be done as quickly as possible to reduce the amount of vapours being released into the environment. All drainage from fuel storage areas shall be diverted to the settling ponds.

No underground storage tanks will be allowed on site.

3A-6.6 Storage and handling of explosives

The storage of explosives will be permitted under the following circumstances:-

- Explosives are stored securely off site by a qualified subcontractor and brought in each working day as required. All explosives to be used up or returned to the off-site storage area.
- The contractor may establish a secure explosives and detonator magazine for the storage of explosives on site.

The contractor shall submit a proposal as to the design and siting of such a magazine to the RE before approval and representation is made to the relevant authorising and permitting authority. The contractor will be responsible for the safeguarding of such a magazine.

3A-6.7 Servicing and washing of vehicles and plant

All vehicles and plant shall be maintained to ensure that there are no leakages. All contaminated surfaces, especially compacted subgrade, shall be removed from site.

A dedicated vehicle wash bay shall be created. The wash bay shall be upon a screed platform to prevent erosion and infiltration of the pollutants into the ground water. All run-off from the platform shall be contained by bund walls. The wash water should be directed via a lined channel to a settling pond. The contractor shall provide and maintain bund walls around the wash bay within the site. Where the drain passes through or across the bund wall the contractor shall provide a means of preventing flow so that in the event of a leak all liquids can be contained by the bund walls.

A dedicated vehicle service area shall be created. Minor services will be allowed on the service area. Soil severely contaminated by oil, fuel or chemical leakages shall be removed and disposed of at a site identified by the RE. All major servicing of plant and vehicles will be done off site, at the contractor's premises.

All used oil shall be retained and disposed of by removal for recycling at an urban centre or disposal in any other manner approved by the ECO. The contractor shall educate workers on the appropriate methods for workshop maintenance and fuel points to prevent fuel and oil being washed out of containment areas.

The contractor will provide a concave concrete floor slab to prevent erosion and infiltration of the ground water by petroleum products. The slab shall drain into the temporary oil skimming tank. The contractor shall provide bunded walls around the maintenance area. Where the drain passes through or across the bund wall the contractor shall provide a means of preventing flow so that in event of a leak or overflow from the skimming tank all liquids can be contained by the bund walls.

All major spillage of oil onto concrete surfaces shall be controlled by the use of an approved absorbent material such as Ociansorb, Drizit or similar.

3A-6.8 Storm water management

Drainage / contaminated water shall flow into a settling pond with a minimum detention period of 10 days. The purpose of the settling ponds is the temporary detention of contaminated water prior to discharge into a natural watercourse to prevent siltation. Construction of the settling ponds shall take place prior to topsoil stripping or any other construction activity upstream. No petroleum products shall be allowed to pass into the settling ponds, by providing suitable oil-skimming facilities. Settling ponds shall be sized by the contractor for approval by the RE. Ponds shall be constructed with suitable materials approved by the RE and shall be watertight. Settling ponds shall be kept empty for as long as possible.

Natural surface flow of uncontaminated storm water across the construction camp shall be separated from the drainage channelled into the settling ponds. This shall be achieved by instituting diversion berms and drains to deflect run-off from these structures.

Separate settling ponds shall be constructed and positioned to collect surface water run-off from spoil areas. The contractor shall remove sediment from the ponds when, in the opinion of the RE and ECO, the effectiveness of the ponds is compromised through sediment build-up. Removed sediment shall be disposed of in a manner acceptable to the ECO according to the condition of the sediment.

All water released from the settling ponds shall be evenly dispersed through, and over grasslands to filter the silt-laden water (no channel to be constructed). At least 90% grass cover of minimum height 150mm shall occupy the land down-slope of the discharge area.

3A-6.9 Quarry and crusher site operation

As much material as possible must be sourced from existing commercial sources. If it is not possible to source suitable materials from commercial sources, new borrow pits must be established. These borrow pits must be approved by the appropriate authorising body and designed properly before they may be used. The following principles must be applied:-

The position of borrow pits must be determined by the ECO and RE bearing in mind the following:-

- The visual impact of the borrow pit.
- The context of the borrow pit, i.e. will traffic, noise and air pollution created by the borrow pit going to adversely affect the surrounds.
- The loss of arable land and grazing.

All topsoil removed from the borrow pit site is to be stored for later rehabilitation of the land. The progression of stripping and excavation shall allow for rehabilitation on areas that have been fully used. Cut slopes shall be a minimum of 1: 3. Borrow pits shall be used for excess rock spoil. Storm water cut-off drains shall be provided at the tops of cut slopes

Excavations shall be undertaken in a safe manner in compliance with the relevant safety regulations. Safety operations to be observed by the contractor shall include the sloping, stepping or benching or shoring, timbering or otherwise supporting the sides of the excavations. Maintaining the sides of the excavations in a safe condition shall at all times be the sole responsibility of the contractor. No under-cutting of the sides will be allowed.

Water and runoff collected in the excavation site will be pumped out of the excavation and released through a sump system into one of the sedimentation ponds before being released into the natural environment.

The contractor shall suppress the dust and noise nuisance caused by the blasting, excavation, crusher and screening processes. These processes shall be positioned so as to cause minimal disturbance to surrounding properties.

3A-6.10 Sanitation on site and worker health

Adequate chemical latrines shall be provided for all staff at the camps and away from the construction camp where labourers are working.

Alternatively, for the construction camp, latrines and septic tank system could be used. This shall be located away from such sensitive areas as sponges, streams and springs and areas of cultural and historical importance. They shall be serviced regularly so as to prevent overflowing. Night-soil shall be removed to a waste water treatment works (WWTW) or disposed of in any other manner acceptable to the ECO. All fees in this regard, whether it be to the WWTW or to the transporter are payable by the contractor.

The contractor's staff shall use only the latrines for ablution. Water used for sanitation purposes e.g. washing facilities must be conducted into the septic tank system.

3A-6.11 Noise pollution and abatement

Noise will be generated during the construction phase by construction activities on site, blasting, plant and heavy machinery, construction traffic and peripheral noise such as shift sirens. Construction plant will be the main source of noise pollution on site. Means of reducing noise emissions and the impact of noise will include performing regular maintenance on all construction vehicles and installing bafflers on vehicles. The contractor will ensure that all vehicles brought to site are within noise emission standards and that they remain that way throughout the contract.

Machine working hours will be restricted between 07:00 and 17:00. Permission to operate outside these hours must be obtained from the RE and the ECO and shall be communicated to neighbouring communities. Sirens, hooters, alarms and other inherently intrusive noises must be removed or be altered so as not to be audible over any significant distance from the site, where not required.

Blasting must be conducted through the middle of the day, as described in Section 3A-6.15.2 and all site neighbours that will potentially experience effects of the blast, be it vibrations or noise, will be informed in writing and through personal communication via a dedicated spokesperson, of the intention to blast.

Careful on-site planning of plant location and working methods must be done to minimise the number of vehicle movements. All on-site activity producing noise discernibly louder than ambient noise must be limited to specified construction hours. Personnel must be informed about the importance of noise restrictions and trained in methods of implementing these strategies.

3A-6.12 Construction procedures related to clay liners and geo-synthetic membrane liners and quality control

Extreme care must be taken with the construction of the liner system, as the quality of construction could influence the later performance of the system. Under no circumstances

will damage to any of the clay or geo-membrane layers outside the technical specifications be accepted by the RE and ECO. Each layer of construction will be approved by the RE and the ECO prior to the construction of the next.

Only properly trained personnel with experience in this regard will be used to handle liner materials and to construct the liner system. All personnel will receive awareness training as to the potential implications of damage to the liner system.

Geo-synthetic liner material rolls shall be packed, transported, offloaded, stored and placed strictly as per the manufacturer or supplier's instructions. No damaged liner material rolls will be accepted for placement.

3A-6.13 Management of spills of fuels and lubricants

This section covers the reaction procedures pertaining to minor and major spills of fuels, lubricants or any other contaminants on the construction site.

3A-6.13.1 Minor spills

If a minor spill of fuel or oil on an area that is not bunded, or does not drain into an oil skimming facility, is detected early enough and treated with suitable absorbent material, soil contamination can be averted. However, if soil contamination is evident, the procedure stipulated below will be followed.

Recommendations for the volume or toxicity of substance spilt which will constitute an emergency (for which the procedure stipulated below will be followed), are given in the South African Department of Water Affairs and Forestry's Minimum Requirements for Hazardous Waste disposal.

Detailed records of all spills on the site, including nature, date and time, position, possible causes, potential environmental impact and mitigatory actions taken will be recorded by the contractor and submitted to the ECO for follow-up.

3A-6.13.2 Major Spills

Any soil contaminated by a significant spill of fuel or other contaminant outside the bunded area will be removed and taken to a permitted landfill or alternative approved by the ECO according to the nature and level of contamination. All removed soil will be replaced with clean imported topsoil and the area re-vegetated as soon as practicable. Recommendations for the volume or toxicity of substance spilt which will constitute an emergency are given in the South African Department of Water Affairs and Forestry's Minimum Requirements for Hazardous Waste disposal. The spill will be addressed by firstly containing it if possible to minimise the environmental impact. The environmental impact of an incident or accident is to be determined, also including the possible cause of the spill, recorded and appropriate mitigation or rehabilitation proposed. The proper execution of the rehabilitation work is to be done whilst complying to all relevant local and international safety precautions for work on the airport property.

Major spills on the paved area draining into the oil skimming facility must be contained on the paved area and pumped into a suitable container to ensure that the oil skimming facility does not overflow due to the volume of material spilt.

There must be proper protective equipment for, and training in, the handling of spilt hazardous substances for personnel dealing with spills or leaks as well as first aid available.

Detailed records of all major spills on the airport grounds, including nature, date and time, position, possible causes, potential environmental impact and mitigatory actions taken will be recorded by the contractor and submitted to the ECO for follow-up. If possible, photos will be taken of major spills.

3A-6.14 Temporary storage and handling of construction and domestic waste

This section deals with the handling and temporary storage of construction and domestic waste on site prior to removal and is divided into a section on construction waste and a section on domestic waste.

3A-6.14.1 Construction Waste

As far as possible, spoil shall be used in fill and contouring of slopes. Only nominated spoil areas shall be used. These shall be located in an area decided by the ECO and shall preferably be previously disturbed areas. Spoil areas shall be contoured to conform to the surrounding landscape and shall covered with topsoil. Spoil heaps shall be protected from run-off by cut-off and diversion trenches. Temporary storage of construction spoil shall be limited, as far as possible, to the road reserve. Areas already disturbed or to be disturbed by construction activities shall be used for storage of spoil. As much construction waste as possible must be re-used or recycled. The contractor will be responsible for removing and transporting all remaining waste material off site to an approved dumpsite.

3A-6.14.2 Domestic Waste

Recyclable waste, including glass, paper and plastic shall be separated at source, stored and recycled, where economically feasible. Waste must be disposed of on a weekly basis in a manner approved of by the ECO at the Contractor's expense.

Personnel shall be informed about the necessity to refrain from littering and about the need to keep hazardous substances separate from the domestic waste. The contractor shall, on alternating days, conduct site clean-ups for litter other than construction spoil, and dispose of it in refuse bins provided on site.

3A-6.15 Construction procedures, including drilling and blasting, cut and fill, stockpiling, concrete work, asphalt work and layer works

This section deals with various typical construction procedures and is applicable to all construction areas where these activities occur.

3A-6.15.1 Drilling

The contractor shall comply with the relevant local and international safety regulations in providing safe drilling conditions and working equipment for his personnel.

Drilling shall commence and end at specified times agreed to and approved by the RE, in order to minimise the noise impact. The contractor shall suppress the dust and noise nuisance caused by the drilling processes. The drilling shall be positioned so as to cause minimal disturbance to surrounding properties.

3A-6.15.2 Blasting

All blasting shall be conducted in terms of the relevant local and international safety regulations. Blasting shall be limited to a specific period of the day so as to minimise disturbance. This time schedule is to be determined and approved with the RE. It is recommended that blasting take place between 12h00 and 15h00. All surrounding communities shall be informed of the blasting time schedule. The blasting time period must be announced prior to blasting by siren. The contractor shall suppress the dust and noise nuisance caused by the blasting processes. The blasting shall be positioned so as to cause minimal disturbance to surrounding properties.

All workmen engaged on blasting at the site shall be experienced in this work and shall be familiar with any explosives regulations.

Where blasting is required every precaution shall be exercised to protect the works and persons, animals and properties in the vicinity of the site. The contractor shall complete pre- and post-blast surveys in the vicinity of the site with the assistance of the RE. In his survey he will check for injured persons, injured animals, damaged property and damaged vegetation identified earlier as being of conservation significance and will take note of fly rock that has exceeded the influence sphere. The contractor shall be responsible, and compensate for all injury and damage occasioned by any blasting operations.

The contractor shall take measures to limit fly rock. This may be achieved by matching the charge to the rock type, by using milli-second delay detonators or by using rubber blasting mats etc. No blasting shall be carried out until permission has been obtained in writing from the RE, who may prohibit the use of explosives near pipelines, cables, roads and concrete already placed and who may restrict the size of charges. At all times blasting shall be carried out such that ground vibration, air blast and scatter are kept within such limits as to avoid damage to adjacent structures or concrete already placed at the works. Peak particle velocity may be restricted to 50 mm/sec or less at the discretion of the RE.

Where there is a possibility of shattering rock, the Engineer may order the contractor to cease blasting and continue to excavate the rock without the use of explosives, by barring, breaking, wedging, line drilling or other approved methods.

3A-6.15.3 Cut

Non-rock slopes shall not be steeper than 1v:2h, although the ideal profile for re-vegetation purposes lies between 1:3 and 1:4. Steep slopes should be protected against erosion with soil stabilisation mechanisms. If the upper slope of the cut face is likely to be unstable, leading to rockfall, then it must be stabilised as soon as possible to prevent erosion. Bare rock on cut embankments ,must not be topsoiled, but only stabilised. Blending with the surrounding environment shall be accomplished through shaping the cut slopes to reflect the natural landscape and rounding the edges of cuts.

3A-6.15.4 Fill

Steep slopes must be protected against erosion. Bare rock on fill embankments must be stabilised and not topsoiled. Blending with the surrounding environment shall be accomplished through shaping the fill slopes to reflect the natural landscape and rounding the edges of fills.

3A-6.15.5 Stockpiling

Suitable material shall be stockpiled on a sub-base platform, which has been cleared of topsoil as described above. The sub-soil will be compacted to accommodate the stockpile. The top surface of all permanent stockpiles shall be left smooth and even and side-slopes, where required, are to be stabilised for the material concerned. Adequate drainage of the top surface and side-slopes shall be provided to prevent erosion.

3A-6.15.6 Concrete work

The concrete batch plant shall be located on a compacted earth platform. Concrete shall only be mixed in areas which have been specifically demarcated and established for this purpose. Any large quantity of concrete spilt shall be promptly removed by the contractor to an approved disposal site or saved for possible later use. After mixing is complete all waste shall be removed from the batching area. The contractor should first seek means of reducing the waste through re-use on site e.g. rubble or recycling. Disposal at an approved disposal site should only be a last resort. No storm water shall be permitted to flow through the batching site.

All water left over from the concrete batching operation or surface run-off from batching area will be channelled to evaporation ponds. These ponds will be cleaned at least twice per year. The batching plant shall be enclosed by a bunded wall with divisions and dedicated compartments for the various types of materials. Air filters shall be monitored and cleaned and replaced on a regular basis.

3A-6.15.7 Asphalt work

The heating of asphalt or bituminous sealant shall be conducted such that the possibility of injury to bystanders or workers is minimised. Care shall be taken to ensure that only those with suitable training and safety equipment are allowed near the placing of hot asphalt or

bituminous sealant. Any unused asphalt or sealant shall either be stored appropriately, such that it does not contaminate any runoff, or safely disposed of as approved by the ECO.

Bituminous products shall be treated as hazardous substances. The manner in which they are to be stored has to be approved by the ECO. If these products are to be stored on site, they shall be stored in tankers or in tanks that are stationed in a secure area on a concrete platform. These storage tanks and tankers shall be clearly marked. They shall be handled by correctly trained and equipped personnel. They shall be contained in a bunded area with the drainage requirements the same as for the storage of fuels.

3A-6.15.8 Layer works

Layer works shall be placed and compacted with dust being minimised through appropriate watering. No work shall be allowed in excessively windy or rainy conditions, as decided by the RE. Stabilising agents shall be used such that they do not cause contamination of groundwater.

3A-6.16 Personnel education and behaviour

Working hours will be agreed upon with the affected communities prior to construction.

Cooking facilities shall be provided for the construction staff within the confines of construction camps. No trees or natural vegetation shall be removed for the making of fires. No fires shall be permitted, unless a specifically designated area has been identified and set aside by the RE for that purpose. Where there is a particular fire hazard at any point in the construction works the contractor shall ensure that his employees are properly trained in the use of the appropriate fire fighting equipment and that such equipment is on hand at all times.

The contractor shall take all measures necessary to prevent his staff from hunting, capturing or destroying animals and birds in the vicinity of the construction camp. The contractor shall take all necessary precautions against trespassing on adjoining properties and shall take care that all livestock, game or vegetation are not interfered with.

The contractor shall ensure that suitable safety regulations and precautions are established and brought to the attention of the personnel. Construction hats and other protective clothing shall be worn at all times whilst on site. The contractor shall comply with all safety regulations regarding the electricity supply and he shall take every precaution to ensure the safety of all the people on site.

The contractor shall ensure that as far as practicable, suitable arrangements are made on site for the maintenance of health, the prevention and overcoming of outbreaks of disease and of adequate first aid services.

The contractor shall be responsible for his own security arrangements and shall comply with any security instructions which the RE may issue from time to time.

The contractor shall, at his own cost, provide for a constant supply of potable water for human consumption to the site offices and other domestic use on site. The contractor shall allow for chemical testing of water samples.

The contractor shall ensure that his personnel is educated and informed as to the requirements of the EMP. A copy of the EMP must be kept on site. The contractor shall endeavour to ensure that his staff complies with the EMP requirements for best practice as described by this document.

3A-6.17 Re-vegetation and rehabilitation after construction

This section covers the proposed rehabilitation actions required after completion of construction, or a section of construction, as well as re-vegetation procedures for rehabilitated and other disturbed areas.

3A-6.17.1 Rehabilitation actions after construction

Rehabilitation will be required at the construction camp and surrounds, the borrow pit or quarry, the crusher site, areas used for the stockpiling of material, other disturbed areas and temporary site roads and pedestrian paths.

All concrete slabs will be broken up and the rubble removed to an approved waste disposal site, or used in the rehabilitation of the borrow pits if approved by the ECO. Surfaces below concrete slabs must be checked for any contaminants and if found contaminated soil must be removed as per section 3A-6.13.2. These surfaces, as well as all areas compacted under material stockpiles, are to be shallowly ripped and topsoiled. Topsoil will be replaced at depths of 100mm to 150mm. Topsoil should always be placed and spread when it is dry by means of hand raking or mechanical blading and trimmed to a uniform thickness not less than 100mm.

All temporary construction water and sewer pipes must be removed with the septic tank and excavations closed with compacted material.

Access roads and other temporary site roads and pedestrian paths where vegetation has been removed or destroyed, will be ripped and topsoiled (if required).

Borrow pits will be filled with as much excess fill material as possible, but shall be kept free of any other waste with the exception of concrete rubble, if approved by the ECO. If concrete rubble is disposed of in the borrow pits, it has to be placed at the bottom to ensure that it does not protrude after topsoiling. Borrow pits shall be covered up with soil from the original excavation of the borrow pit, or material from other approved sources.

No rehabilitated area will be left vulnerable to erosion and erosion will be monitored for erosion channels forming. Eroded areas will be repaired to limit the damage as soon as possible. All rehabilitated areas will be re-vegetated as per section 3A-6.17.2 below and will be protected from excessive trampling and vehicular access.

3A-6.17.2 Re-vegetation after rehabilitation

Re-vegetation of herbaceous cover and grass cover shall be of natural indigenous species occurring in the general environment of the site. Where natural indigenous species are not commercially available, acceptable non-invasive species approved by the ECO shall be used.

An acceptable grass cover shall mean that not less than 80% of the seeded area be covered with grass and there shall be no bare patches of more than 500mm in diameter. The normal minimum application rate of seeds is 25kg of seed per hectare. Seed should be applied as per the supplier's guidelines. A fertilizer, 2:3:2 shall be added to the seed mix prior to seeding. On completion of the seeding the area shall be lightly raked parallel to the contours to cover the seed. A superphosphate shall be mixed into the soil during scarification. Areas that show now vegetation growth 9 months after completion of the rehabilitation work, will be ripped, additional topsoil spread and seeded with indigenous grass species.

If hydro seeding is preferred by the contractor, cellulose pulp must be added to the seed mix at a rate of 1500kg per hectare. If a soil stabiliser is used, the pulp can be omitted or used at a reduced rate. Alternative seed mixtures or sowing techniques used does not change the contractor's responsibility to achieve adequate cover.

Tree and shrubs planting shall be done in naturally positioned mixed clumps to blend in with the natural species communities, as per the instruction of the ECO. Trees and shrubs kept in the site nursery will be used for this purpose, supplemented by additional planting material sourced commercially, if in the opinion of the ECO the nursery plants were not properly maintained during the construction phase.

All re-vegetated areas will be protected from excessive trampling and vehicular access.

Section 3A-7 Monitoring and Auditing During Construction Phase

This section covers the monitoring and auditing requirements during the construction phase and includes sections on the environmental management committee, reporting and meeting requirements and testing frequencies.

3A-7.1 Environmental management committee

An environmental management committee is to be established for the construction phase of the project. This committee could comprise:-

- The RE (Chairman)
- Representative(s) of the contractor
- Representative(s) of MICOA
- The ECO
- An Environmental Auditor
- Representative(s) of the local community

In addition to the responsibilities of the RE and ECO detailed in this report, the various members of this committee will have the administrative responsibilities tabulated below.

Member	Responsibility
Resident Engineer (Chairman)	1. Liaison between Contractor and all other parties
Contractor's representative(s)	1. Assisting in evaluation of construction/monitoring methods 2. Assisting the ECO with testing and monitoring where required
MICOA representative(s)	2. Confirming compliance with environmental policy and legislation on site 2. Liaison with MICOA
ECO	1. Compiling of monthly and non-conformance reports 2. Conducting of pollution monitoring and monitoring as per this EMP 3. Liaison with MICOA 4. To take minutes of the environmental management committee meeting
Environmental Auditor	1. Reporting on auditing of EMP implementation. 2. Provide guidance on EMP monitoring on site by the ECO 3. Act as external advisor if required
Representative(s) of the local community	1. Liaison with the local community

3A-7.2 Reporting and meeting requirements

Monthly meetings will be held involving all the members of the committee, with the exception of the external auditor who will attend only to report back after an audit, or if specifically requested to attend. The purposes of the meeting shall be:-

- To establish the suitability of the Contractor's methods and machinery in an effort to lower the risk involved for the environment
- To discuss possible non-conformance to EMP guidelines or environmental legislation
- To assess the general state of the environment on site and discuss any environmental problems which may have materialised
- To act as a forum for input into the construction phase by the MICOA representative and external environmental auditor
- To accommodate the local community in the decision-making process regarding social and environmental issues on site

Two kinds of reports should be compiled by the ECO for study by the external environmental auditor and/or MICOA:-

- A monthly report which will include
  1. results of any atmospheric, water or noise pollution tests performed as per this EMP in the specific month. This testing will be conducted either by an outside contractor or by the ECO with equipment acquired for the project.
  2. a description of exceptional conditions on site whether they be meteorological, personnel related, machinery related or otherwise
  3. a description of any environmental accident or developments which could potentially develop into a non-conformance event by the contractor
  4. minutes from the Environmental Management Committee meeting

- A non-conformance report which will describe, in detail, the cause, nature and effects of any environmental non-conformance by the Contractor and could stand as evidence should legal action be required. A testing sheet for atmospheric, water and noise pollution must be included for each infringement indicating the details of the event including position on site, date and time. If possible a photo should also be included in the report. This report will also suggest mitigatory measures to correct the non-conformance (if necessary) and contemplate revisions to any of the strategies used in the construction phase, whether they pertain to monitoring or to construction methods used on site.

3A-7.3 Testing frequencies

Compliance monitoring and testing will be done as per this EMP to monitor EMP implementation and compliance and initiate corrective action if required. The ECO will develop sample sheets for regular monitoring and testing, as well as establish a proper filing system for record keeping purposes.

Testing frequencies for different aspects are listed below:-

- Potable water quality monitoring – every 2 weeks and more often if specific complaints are received from personnel or labourers
- Discharge water quality monitoring - every 2 weeks and more often if specific complaints are received from personnel or labourers
- Air quality monitoring – every month for the duration of earthworks, blasting and other dust-generating activities and when specific complaints are received from the communities surrounding the site
- Noise monitoring - every month for the duration of earthworks, blasting and other noise-generating activities and when specific complaints are received from the communities surrounding the site

SECTION 3B : OPERATIONAL PHASE OF FACILITY

SECTION 3B
OPERATIONAL PHASE OF FACILITY

TABLE OF CONTENTS

Section 3B-1 Introduction

This section of the EMP should be read with the Mavoco Hazardous Waste Facility **Operating Plan**. It focuses on the significant issues to be addressed during the operations phase and specifies monitoring and auditing criteria for this phase.

Section 3B-2 Summary of project description, site description, location and layout, as well as a description of site facilities.

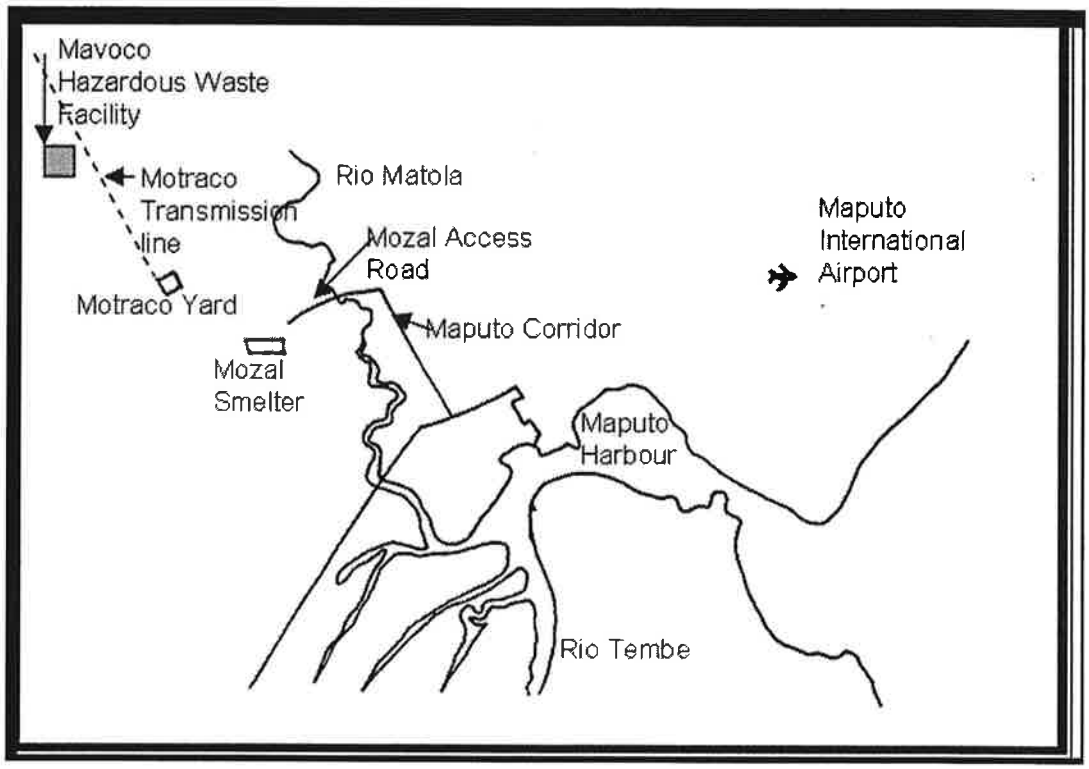
3B-2.1 Project Description

MICOA and MOZAL have a need for a hazardous waste treatment and disposal facility near Maputo for the safe disposal of Hazardous waste materials generated by the Mozal Aluminium Smelter, as well as by other industries in Mozambique. To this end MICOA, with assistance from DANIDA, a site for the development of such facility was identified.

During November 2001 the broad scope of the hazardous waste disposal facility was agreed as the design and construction of a facility that can be used to receive, characterise, record and safely dispose of hazardous waste. Supporting infrastructure required is an access road and services including water and power. The proposed facility does not include any form of waste destruction capability, but could, however, be added in future. The principle waste disposal function at the facility will be landfill and this will take on the form of dedicated lined cells that meet the requirements of H:H landfill class (High and Extreme Hazard Rating as defined in the South African Minimum Requirements). This project therefore deals with the establishment, operations and ultimately closure of an extreme and high classed hazardous waste disposal facility in Mozambique.

3B-2.2 Site location and layout

The site is located in the Beluluane area, District of Boane, approximately 10km west-north-west of the Mozal Smelter, on the south side of the Motraco power line from South Africa. The total area of the site is approximately 50ha, although only 10ha is required for the initial establishment of the facility infrastructure. The initial establishment involves a 5 year cell plus 10 year infrastructure with provision for future expansion to 20 years. The site is approximately 7,7km from the Motraco switchyard. The proposed access road mainly follows the Motraco power line



3B-2.3 Site description

The topography of the site is gently undulating, with an average slope of about 2% in a westerly direction. Elevations vary from 65m on the west side to about 80m above mean sea level on the east side of the site. Drainage is westwards towards the Rio Movene (Xingube), which flows in a southerly direction approximately 500m from the site. The Rio Movene is a seasonal stream that is dry for large periods during the year. Approximately 1km to the east of the site, there is a gentle ridge of elevation about 90m above mean sea level that forms a watershed between the Rio Movene and the Rio Matola. There is therefore a relatively small catchment area above the site. Apart from minor seasonal gulleys towards the southern and western sides of the site, there are no distinctive drainage courses on the site itself.

3B-2.4 Description of facilities on site

The main entrance to the site is to be located on the north western side of the site, to link up with the planned access road running parallel to the Motraco power line. The majority of the facility infrastructure would be located on the north western side of the site.

The components of the project will comprise of the following:

- one landfill cell with operational dividing bund walls,
- a leachate buffer and management system,
- temporary waste storage system,
- access road, weighbridge,
- operational hard surfaced areas,
- storm water (contaminated and uncontaminated) management system
- administration buildings/workshops,

- laboratory,
- waste stabilisation unit,
- fire protection system,
- bore hole water supply,
- sewerage systems,
- fencing,
- power and lighting and a telephone system.

Section 3B-3 Establishing Statutory and Legal Requirements

An Environmental Impact Assessment (EIA) was done for the development of the facility and the access road. As part of the fulfilment of the EIA requirements of MICOA, an Environmental Management Plan (EMP) has to be prepared for the operations and management of the facility.

This EMP aims to ensure compliance to the Mozambican Statute No 48/73: Occupational Health and Safety in Industrial Premises and the Mozambican Labour Law of 20 July 1998, as well as the South African Occupational Health and Safety Act (Act No 85 of 1993) on the landfill site.

The Contractor is required to comply with all acts, regulations, bylaws standards and guidelines applicable to the nature of the work. As all parties involved with the project have in the absences of local legislation agreed to comply with the relevant South African legislation. The disposal facility operating contractor shall therefore also comply with the stated legislation which include, where applicable and as amended, but not limited to:

3B-3.1 Mozambican Legislation

- The Framework Environmental Law Act 97 of 1997

3B-3.2 South African Legislation

- The National Water Act No. 36 of 1998 – "The Minimum Requirements Series".
- The Occupational Health and Safety Act 85 of 1993.

3B-3.3 International Agreements

Both these international agreements have been signed and ratified by the Mozambique Government.

- The Bomako Convention (1991): Convention on the ban of the import into Africa and the control of transboundary movements of hazardous wastes within Africa
- The Basel Convention (1989): Convention on the control of transboundary movements of hazardous wastes and their disposal.

3B-3.4 Management Systems Requirements (ISO 14001)

The Contractor shall ensure that the site is managed in accordance with the requirements of the ISO 14001 Standard and with the Operating Manual. The Operating Manual may be amended by MICOA from time to time. Landfill audits conducted by MICOA and/or external parties will be done to ensure that legislative requirements, the ISO 14001 Standard and the Operating Manual are complied with. ISO standards that need to be complied with include:

- SABS ISO 14001 (1996): Environmental Management Systems – Specification with Guidance for Use
- SABS ISO 14004 (1996): Environmental Management Systems – General Guidelines on Principles, Systems and Supporting Techniques
- SABS ISO 14010 (1996): Guidelines for Environmental Auditing – General Principles
- SABS ISO (1996): Guidelines for Environmental Auditing – Audit procedures – Auditing of Environmental Management Systems
- SABS 0228: Identification and Classification of Dangerous Substances and Goods

Section 3B-4 Applicable Standards and Management Criteria

The standards and management criteria applicable to this phase of the project include water quality standards for both potable water supply and effluent discharge from the site, air quality standards and noise standards. Due to the lack of local standards and the sensitivity associated with the handling and disposal of hazardous waste, accepted regional SADC standards, such as the South African SABS standards will be referenced.

3B-4.1 Water Quality Standards: Potable Water and Effluent Discharge

The acceptable levels of water quality parameters are given below. Testing will be performed either by an International Organisation for Standardisation (ISO) 9000 accredited laboratory or by an on-site laboratory, which will entail the acquisition of testing equipment. All test equipment will be calibrated every six months and records of calibration will be kept by the relevant laboratory.

The two columns on the right of the table indicate the applicable standards which will be met for potable water usage and for contaminated water / leachate release into the environment. A shaded cell indicates that the specific element will be tested for.

It must be borne in mind that this list of contaminants is by no means exhaustive. In the event of any spillage of suspected hazardous nature, the MICOA will be consulted to determine whether a more substantial list of contaminants should be tested for, based on the nature and extent of the spill.

Effluent samples will be taken according to the procedures of SABS 241.

Variable	Unit	Limit	Potable Water	Leachate/ Contaminated Water
Colour, Odour, Taste	-	Not discernible		
PH	-	6-9		
Dissolved Oxygen	Saturation	80%-120%		
Total coliforms	Counts/100ml	0-5		
Faecal coliforms	Counts/100ml	0		
Temperature change from natural water temp(point f)	°C	≤2		
COD	mg/l	75		
BOD	mg/l	10		
Total Suspended Solids	mg/l	25		
Aluminium	mg/l	≤0.005		
Ammonia	mg/l	≤0.007		
Arsenic	mg/l	≤0.01		
Asbestos	fibres/l	$\leq 1x10^6$		
Free available chlorine	mg/l	0.3-0.6		
Calcium	mg/l	16-32		
Chloride	mg/l	0-100		
Chromium(VI)	mg/l	≤0.007		
Chromium(VI)	mg/l	≤0.012		
Copper	mg/l	≤0.0003		
Cyanide	mg HCN/l	≤0.001		
Electric Conductivity	MS/m	≤70		
Endosulfan	µg/l	≤0.01		

Variable	Unit	Limit	Potable Water	Leachate/ Contaminated Water
Fluoride	mg/l	≤0.75		
Iron	mg/l	≤0.1		
Lead	mg/l	≤0.0002		
Manganese	mg/l	≤0.05		
Mercury	mg/l	≤0.001		
Nitrate	mg/l	≤6		
Nitrogen(N) (Inorganic)	mg/l	≤0.5		
Phenol	mg/l	≤1		
Phosphorous(P) (Inorganic)	N:P ratio	≤25-40:1		
Selenium	mg/l	≤0.002		
Sodium Content	mg/l	0-100		
Sulphates	mg/l	≤200		
Total Dissolved Solids	mg/l	≤450		
Turbidity	NTU	≤1		
Zinc	mg/l	≤0.002		

3B-4.2 Air Quality Standards

The likelihood of unacceptably high air pollution during the operations phase, apart from dust nuisance, is low. Only Total Suspended Solids, Smoke and Dust Fallout will be measured during this phase. Other pollutants will be measured when an obvious nuisance occurs, for the purposes of prosecution or mitigatory action, as directed by MICOA. Air Quality testing will be performed by an ISO 9000 accredited laboratory.

Applicable standards for the measurement of total suspended solids, smoke and dust fallout are:-

Total Suspended Solids:	24 hr average – 300 microgram/m^3
Smoke:	24 hr average – 250 microgram/m^3
Dust fallout (Deposition):	Slight – less than 0.25 g/m^2/day
	Moderate – 0.25-0.5 g/m^2/day
	Heavy – 0.5-1.2 g/m^2/day
	Very heavy – more than 1.2 g/m^2/day

The 24 hr limits are not to be exceeded more than 3 times per year.

3B-4.3 Noise Standards

The various applicable standards pertaining to the construction activities expected at the facility and access road include the following list:-

- SABS ARP 020:1992 – Sound Impact Investigations on Integrated Environmental Management
- SABS 0210:1996 – Calculating and Predicting Road Traffic
- SABS 0103:1994 – The Measurement and Rating of Environmental Noise with respect to Annoyance and to Speech Communication
- BS 5228 –1 – Noise Control on Construction and Open Sites – Part 1: Code of Practice for Basic Information and Procedures for Noise control.

SABS 0103:1994, in particular, is useful in identifying acceptable noise performance levels. Table 6 of this standard stipulates various increments of sound level increase, and the concomitant subjective impact experienced by the community experiencing it. This table will thus be used as a guideline for requirements espoused by the construction site.

Noise monitoring will be done on the assumption that the vast majority of plant and machinery fall within the acceptable noise levels. Where gross transgressions of noise regulations and guidelines exist, measurement and punitive action will be taken. It will be most appropriate to enlist the services of an ISO 9000 accredited acoustics laboratory rather than incur the cost of permanent monitoring equipment.

The SABS Codes Of Practice SABS 0103:1994 *The measurement and rating of environmental noise with respect to annoyance and to speech communication*, gives guidance as to acceptable noise levels. SABS 0103:1994 uses the unit of dBA, which is the

unit of a running average of noise over a fairly short period, with prescribed guideline limits for this parameter. The predominantly rural environment around the proposed site would be affected to a greater degree than other settings by the same level of noise. The appropriate noise limits are listed for different environments. SABS 0103:1994 uses the method of identifying typical ambient noise levels at each specific location and then to stipulate noise increases of increasing irritation to the receiver.

Typical ambient noise rating level (dBA):-

District	Daytime	Evenings/weekends	Night time
Rural (outside)	45	40	35
Quiet suburban (outside)	50	45	40
Urban (outside)	55	50	45
Industrial (outside)	70	65	60

Table 6 from the SABS 0103:1994, categorising expected group or community responses, is given below:-

	Estimated community/group response	
Excess ΔL_r / dB	Category	Description
0	None	No observed reaction
>0 ≤ 5	Little	Sporadic complaints
>5 ≤ 10	Medium	Widespread complaints
>10 ≤ 15	Strong	Threats of community group action
>15	Very strong	Vigorous community group action

Section 3B-5 Overarching Environmental Objectives During the Operational Phase

The design and construction of the hazardous waste facility is aimed at minimumizing adverse impacts on the environment provided the approved operation plan is adhered to. Placing the waste in a contained system ensures no or nominal pollution of the physical environment such as water, air and the ground.

Correct procedures followed by the operating contractor during the operational phase shall ensure minimum or no:

- Pollution of the groundwater by containing the waste inside the landfill
- Air pollution by applying daily cover and by applying dust control.
- Pollution of the ground by on and around the site through proper housekeeping.

The monitoring of operations and procedures shall be done by the Responsible Person, the Environmental Officer and Monitoring Committee. The records thus obtained shall be audited by the external landfill auditor and MICOA. The monitoring and auditing process shall ensure that a high standard of operation is maintained.

Cognisance shall be taken of the local conditions and modus operandi, as they exist in Mozambique.

Section 3B-6 Responsibilities of Environmental Officer (EO) and External Auditor (Monitoring Committee)

This section highlights the responsibilities of the EO and the external auditor in terms of the requirements of the EMP during this phase of the project.

3B-6.1 Environmental Officer

The Environmental Officer (EO) will be appointed by MICOA to oversee the implementation of the operation EMP on site, and will have no contractual or other agreement with the contractor to ensure unbiased judgement. The EO could be appointed full- or part-time, as required by MICOA. It is expected that a minimum of 2 site visits per month for the life time of the landfill facility is required for proper monitoring of implementation.

The EO has the authority to stop the works per formal site instruction notification, if in his opinion there is a serious threat to or impact on the environment due to the construction operations, until such threat or impact has been mitigated successfully. In such cases the EO must inform the Responsible Person (RP) and MICOA as soon as possible.

Upon failure by any employee of the contractor, including the contractor's agent, to show adequate consideration to the environmental considerations as described in this EMP, the EO may recommend that such employee be removed from site. All costs associated with the action will be borne by the contractor.

The EO will keep a site diary to record any significant incidents. This diary will be made available to the contractor, MICOA and the RP upon request. Records of the successful implementation or shortcomings of the implementation will be kept. The implementation status of the EMP will be a fixed agenda point for all site meetings and all outstanding EMP issues will be discussed and implementation actions with due dates recorded.

The EO will request environmental method statements from the contractor for specific sensitive or high-risk actions, at his discretion. It is important to note that the EMP is regarded as a 'live' document that can be changed should more effective methods of mitigation be proposed and accepted by the EO. MICOA will be updated on a monthly basis in this regard. All accepted method statements will be regarded as being part of the EMP documentation and are subject to all terms and conditions contained in the main EMP document. A method statement describes the scope of intended work step-by-step detailing what, how, where and when an action will take place, as well as detail on the proposed

mitigation measures to meet the EMP requirements. No work may commence prior to the approval of the method statement by the EO.

The external auditor will prepare a short audit report after each audit for submission to MICOA.

3B-6.2 External Environmental Auditor

The external environmental auditor will be appointed by MICOA to audit the EO's records of implementation and success of mitigation measures adopted on site. It is expected that a minimum of one audit per 3 month-period for the duration of the operations period is required for proper auditing of the monitoring of implementation. The EMP will be criteria against which the EO will be audited.

Quarterly internal audits (i.e. audits conducted by MICOA personnel) shall be conducted, reports compiled for such audits, and these audits made available to external auditors. Should the Contractor perform audits, the reports of these audits will be forwarded to MICOA and the external auditors for their perusal.

Routine internal audits shall be carried out by the Contractor to check for compliance with the Operating Plan. These inspections should be monthly as specified in the Minimum Requirements. However if the operational aspects of the Site are found to be in compliance with the operational manual and all legislative requirements, the frequency of the audits shall be reduced at the discretion of MICOA. Every six months an external audit by independent consultants should be undertake and the results submitted to MICOA.

The external audits will be carried out by a small team comprising representatives of MICOA, the Consultant and the Contractor, and may include representatives of local or national government departments.

It is noted that in addition to the above audits, the relevant authorities such as MICOA may carry out audits of the site. The Contractor is to allow such authorities access to the Site.

Section 3B-7 Mitigation and management proposals for significant aspects including environmental operational procedures for

3B-7.1 Operating Plan

The site shall be operated on the basis of an **Operating Plan** which is **a site specific document** that will be developed by the designer and developer of the landfill facility. It will describe the way in which the landfill is to be operated, commencing at the level and detail of daily cell construction and continuing through to the projected development of the landfill with time.

Everything pertaining to the operation of a landfill will therefore be included in the Operating Plan, which is subject to regular update.

The Operating Plan will include, *inter alia*, the phasing, the excavation sequence, site access and drainage. It will also include all operation monitoring procedures and a plan for mitigatory actions in response to problems detected by monitoring. In drawing up the Operating Plan, cognisance will be taken of the input of IAPs during the Feasibility Study and Permit Application Procedure. If necessary, certain issues, for example, the phasing of the operation, will be discussed and agreed with the IAPs, to whom access to the final plan will be given. In addressing the monitoring of operation, the Operating Plan will make reference to the role of the Monitoring Committee, which is to include IAPs.

A Response Action Plan will form part of the Operating Plan. The Response Action Plan will detail procedures to be followed in case of failure in the design or operation. It will also include an emergency evacuation plan. For this hazardous waste landfill the Operating Plan will also address all items stipulated in the Major Hazard Installation Regulations, governed under the Occupational Health and Safety Act. All failure modes and effects will be quantified in a risk assessment and on-site and offsite emergency plans will be developed.

3B-7.2 Waste management and disposal of domestic waste generated on site.

This section deals with the disposal of house hold waste (food stuff, packaging, bottles, etc.) generated at the facility and more specifically the administration building, work shops, pump houses, guard house, blending facility, temporary waste storage facility and on site. It furthermore deals with the handling and temporary storage of construction and domestic waste on site prior to removal and is divided into a section on construction waste and a section on domestic waste.

3B-7.2.1 Temporary storage and handling of construction waste

Should there be the need for any construction activity and spoiling of material then spoil shall as far as possible, be used in fill and contouring of slopes. Only nominated spoil areas shall be used. These shall be located in an area decided by the EO and shall preferably be previously disturbed areas. Spoil areas shall be contoured to conform to the surrounding landscape and end-use plan and shall covered with topsoil. Spoil heaps shall be protected from run-off by cut-off and diversion trenches. Temporary storage of construction spoil shall be limited, as far as possible, to the appropriate stockpile. Areas already disturbed or to be disturbed by construction activities shall be used for storage of spoil. As much construction waste as possible shall be re-used or recycled. The contractor will be responsible for removing and transporting all remaining waste material off site to an approved dumpsite.

3B-7.2.2 Domestic Waste

Recyclable waste, including glass, paper and plastic shall be separated at source, stored and recycled, where economically feasible. Waste must be disposed of on a weekly basis in a manner approved of by the EO at the Contractor's expense at an approved general waste disposal site.

Personnel shall be informed about the necessity to refrain from littering and about the need to keep hazardous substances separate from the domestic waste. The contractor shall, on

alternating days, conduct site clean-ups for litter other than construction spoil, and dispose of it in refuse bins provided on site.

3B-7.3 Waste management and disposal of hazardous waste brought to the disposal facility.

This section deals with the management, treatment and disposal of hazardous waste brought to the waste disposal facility.

3B-7.3.1 Classification of waste

3B-7.3.1.1 Access

Prior to waste being accepted at the MAVOCO hazardous waste disposal site, it shall be confirmed by suitably qualified staff and the transporter that the type of waste is suitable for disposal.

Vehicle access shall always be limited to the main gate on the North West of the facility. During hours of operation, the entrances shall be manned and shall be locked when the facility is not in operation, to prevent unauthorised entry. There shall always be sufficient trained staff on site to monitor, control and record incoming waste.

Road access to the landfill working faces shall be maintained at all times in a manner suitable to accommodate vehicles normally expected to utilise the facility. All on-site roads will be so surfaced and maintained as to ensure that waste can reach the working faces with minimum inconvenience in all weather. Roads shall also be regularly graded and wetted to control dust, when necessary. Congestion on the approach and ring road system shall be minimised as far as possible.

3B-7.3.1.2 Waste acceptance

Prior to waste wagons entering the facility, it shall be verified as acceptable waste by the gatekeeper and confirmed with the transporter. All waste will be regarded as hazardous. Vehicles carrying hazardous waste shall be directed to the weighbridge. At the weighbridge the necessary records will be developed.

All hazardous waste consignments shall be:

- classified,
- accompanied by appropriate waste manifest documentation, and
- checked for conformity through spot testing.

Prior to delivery, all hazardous waste consignments shall have been categorised by a laboratory assessment to determine the need for any pre-treatment and special handling, and hence disposal cost.

The following acceptance procedure shall be followed where pre-notification is given and the waste is known.

1. Waste to be disposed of shall be analysed by a laboratory to determine hazard rating, leachability, treatment and disposal methods.
2. A visual and chemical check shall be made of the consignment to ensure that the waste matches that which is to be disposed.
3. Non-conforming and unacceptable waste shall not be permitted to be disposed at the site and shall be returned to the generator.
4. Any irregularities shall be reported to the Responsible Person and action taken immediately to determine the problem and to ensure that the situation does not arise again. Waste shall be held back until the problem has been resolved.
5. Acceptable waste shall be directed to the landfill for disposal, transit waste facility or waste stabilization area.
6. Empty outgoing vehicles shall be cleaned of any contaminants and the details of the vehicle recorded such as the mass, registration number and departure time.

The waste manifest document shall be kept up to date to ensure safe disposal of the hazardous waste load. The gate control room shall always be manned and the approved site acceptance procedures shall be followed over weekends as well. **Upon delivery all administration procedures shall be followed and waste load shall be verified by the on-site laboratory.**

3B-7.3.2 Sampling and laboratory procedures

3B-7.3.2.1 Waste analysis

Although waste may at times be sampled prior to and after disposal the preferred option shall be prior to disposal. Waste shall be sampled:

- For an unknown waste stream which potentially could be hazardous.
- For waste brought to the site unannounced.
- For spot-checks at random intervals.
- When a waste stream continuously does not conform to its expected chemical profile.
- When a waste generating process undergoes changes.

Sampling and analytical procedures shall be based on an acceptable standard methodology and a sampling and analysing methodology manual shall be compiled, to ensure consistency of procedures.

3B-7.3.2.2 Unacceptable wastes

Extremely hazardous wastes that represent a safety hazard for the operators and workers on the landfill shall not be accepted at the site without them being pre-treated at source to render them immobile, less toxic or less reactive. These wastes would include high and low pH substances such as acid-oil sludges, caustic sludges, etc.

Highly toxic wastes, such as PCBs, insecticides, pesticides, etc., will not be accepted for disposal. Medical waste, radioactive waste, compressed gasses, explosive waste, general waste and putrescible waste will not be allowed to be disposed of on this site. Medical waste shall be incinerated at medical facilities in the region, and the resultant ash, which is regarded as hazardous, can be deposited on the landfill. MICOA shall be informed if wastes of this nature have arrived at the site. The operator at the working face shall also ensure that no unchecked hazardous wastes (e.g. hazardous liquids, sludges or even sealed drums) are disposed of.

3B-7.3.3 Pre-treatment of waste

3B-7.3.3.1 Pre-treatment of hazardous wastes

The properties of certain hazardous wastes are such that they cannot be safely deposited directly into the landfill. In such cases, the wastes shall be pre-treated to render them immobile, less toxic or less reactive. Specific reference is made to the *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste.*

Once a waste has been pretreated, the residue is disposed of in accordance with its hazard rating on the landfill. Unidentified wastes are also regarded as unacceptable for landfilling and will require identification, followed by appropriate treatment, pre-treatment or encapsulation.

3B-7.3.3.2 Standard operating procedures

The off-loading of hazardous waste and blending operations will be executed under the jurisdiction of the Responsible Person. The Responsible Person shall ensure that appropriate standard operating procedures are adhered to. Aspects include:

- Ensuring the use of protective clothing (e.g. gloves, goggles and breathing apparatus) by workers
- Ensuring that no incompatible wastes, for example those which could cause explosions or the generation of poisonous gas, (e.g. cyanide and hydrochloride acid) are co-disposed
- Ensuring that the hazardous waste load allocation as specified in the Permit is not exceeded, see also *Minimum Requirements for the Handling, Classificationand Disposal of Hazardous Waste*
- Ensuring immediate and/or daily covering
- Ensuring that there are no free liquid surfaces left at the end of the day's operation caused by whatever operation or circumstance.

It will be required that the Responsible Person and the workers know and can execute the content and the requirements of the Response Action Plan for the site, in case of an emergency

3B-7.3.4 Waste stabilisation

The stabilisation of waste will be done by blending the waste using cement or lime to immobilize the fluorine in the waste. Similar blending operations for other problem wastes such as oil sludges, etc. with ash could also be carried out in this facility. Blending and mixing operations would be carried out using either a TLB or front-end loader, or, for smaller quantities, with a concrete mixer.

To minimise dust release during tipping, water shall be sprayed during tipping manually by using a hose and spray nozzle. In addition to this, to limit dust being generated during blending and mixing, water shall be added to the mixture first, to suppress as much dust as possible.

All personnel working in this area shall be equipped with the relevant PPE (masks, goggles, etc.) during tipping, blending and mixing procedures. Although potable water can be used in the mixing process leachate/contaminated water should be used during the mixing process to preserve energy and the supply of potable water.

3B-7.3.4.1 Storage of Cement

Cement to be used in the blending process shall be delivered in sound and properly secured bags or in approved bulk containers. Cement products in bags shall be stored in an enclosed storage area underlain by a concrete platform with the bags raised off the ground with the use of pallets. The storage facility and surrounding area shall be swept and cleaned regularly as required to ensure that cement products do not enter the surrounding environment. Where cement silos are used, the ground cover surrounding the silo and dispatch area is to be a well graded uncompacted surface. This will ensure that any cement spilt does not splatter or run over the otherwise hard surface and is therefore easier to remove.

3B-7.3.5 Recycling, reclamation and incineration of waste

Recycling, reclamation and incineration of any waste will be absolutely forbidden and under no circumstances will recycling, reclamation or incineration of waste be permitted at this hazardous waste disposal site.

3B-7.3.6 Solid and liquid waste

The disposal of any liquid waste in the landfill is not permitted. All liquid waste shall be pre-treated prior to disposal.

3B-7.3.7 Hazard rating

Prior to delivery, all hazardous waste consignments shall have been categorised by a laboratory assessment to determine the need for any pre-treatment and special handling, and hence disposal cost. Extremely hazardous wastes that represent a safety hazard for the operators and workers on the landfill shall not be accepted at the site without them being pre-treated at source to render them immobile, less toxic or less reactive.

3B-7.3.8 Co-disposal of waste

The design of the landfill facility does not cater for the co-disposal of waste i.e. co-disposal of general waste and hazardous waste (liquid or solid). Therefore the co-disposal of waste is not permitted at the facility.

3B-7.3.9 Landfill Operation

Stringent waste acceptance procedures such as pre-treatment and temporary storage of unknown waste will be adhered to at the Mavoco waste disposal facility along with the principles of sanitary landfilling in conjunction with pre-treatment of the waste.

3B-7.3.10 Sanitary landfilling

The landfill will be operated in accordance with the following sanitary landfill operating principles:

- waste shall be compacted, and
- covered at the end of each day's operations.

3B-7.3.10.1 Compaction

Compaction is best achieved if the waste is spread in thin layers and compacted by a purpose-built landfill compactor. This compaction procedure will be a required at the hazardous waste disposal site.

3B-7.3.10.2 Daily cover

The sanitary landfill definition specifies daily cover. It will therefore be required that the waste be fully covered at the end of each working day. Waste shall be deposited in cells, spread, compacted and covered, so that each day's waste is effectively isolated from the environment. The material to be used for cover will be on-site soil excavated as part of the site development process. In all cases, a strategic stockpile of cover, enough for at least three days, shall be maintained close to the working face for use in emergencies. Suitable equipment and resources will also be available to ensure that there is sufficient cover material, so that no area is left uncovered at the end of the day's operation.

A minimum thickness equivalent to the effective covering of 150mm of compacted soil will be used as part of every day's operation. Where the area is to be left for an extended period, but ultimately to be covered again with waste, the compacted thickness of this intermediate cover shall be increased to 300mm. This is not as thick as final cover, but affords the additional protection required in the longer term.

3B-7.3.11 Methods of landfilling

3B-7.3.11.1 Standard cell operation

The basic landfill unit is a cell of compacted waste which, when completed at the end of each day, is entirely contained by cover material. The sides shall be formed by 2,2m high berms, constructed from soil. A lift will be formed from a series of adjoining cells of the same height. The waste will be deposited by incoming vehicles at the working face which is the active part of the landfill.

The working face will be kept as small as possible for control and covering purposes. The width, however, will be determined by the manoeuvring requirements of the vehicles depositing waste. It shall thus be sufficiently wide to avoid traffic congestion. There will also be sufficient cell capacity on site to accommodate at least one week's waste. To achieve the best compaction results the waste shall be deposited at the bottom of the working face and worked up a 1 in 3 slope. Cover will then be deposited and spread on the top of the cell during the day and extended to cover the working face at the end of the day.

3B-7.3.11.2 Wet weather cell

An easily accessible wet weather cell shall be constructed close to the site entrance or close to an all weather road, for use under abnormally wet weather conditions. The wet weather cell shall have sufficient capacity to accommodate one week's waste. The cell will be constructed in the same manner as the standard cell. It will, however, have a well drained gravel type base in order to ensure vehicle access in wet weather. As far as possible, the wet weather cell shall be operated in the same manner as the standard cell.

3B-7.3.12 Methods of landfilling: Hazardous Waste

This H:H landfill is specifically designed to accept wastes of Hazard Rating 1 or 2 as well as waste with Hazard Rating 3 or 4 according to the *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste*. In cases where a waste is unidentified, the precautionary principle shall apply and the worst case is assumed. The hazardous waste shall be disposed in a specially lined and engineered containment cell.

3B-7.3.13 Disposal of medical wastes

The disposal of medical wastes at the landfill site is prohibited and will thus not be allowed to take place.

3B-7.4 Management of sanitation facilities (including treatment process and effluent discharge monitoring)

The septic tanks and toilets shall be serviced regularly so as to prevent overflowing. Night-soil shall be removed to a waste water treatment works (WWTW) or disposed of in any other manner acceptable to the EO. All fees in this regard, whether it be to the WWTW or to the transporter are payable by the contractor.

The contractor's staff shall use only the latrines for ablution. Water used for sanitation purposes e.g. washing facilities must be conducted into the septic tank system.

3B-7.5 Facilities and Resources required for Landfill Operation

There will be sufficient facilities and resources to ensure that the landfill operation can conform to operating and environmental management plan. For example, there shall be sufficient trained staff to monitor, control and record incoming waste where required.

3B-7.5.1 Signposting and road access

Signs in the appropriate official languages shall be erected in the vicinity of the landfill, indicating the route and distance to the landfill site from the nearest main roads. These traffic signs will conform to the requirements of the Road Ordinance. Suitable signs will also be erected on site, to direct vehicle drivers appropriately and to control speed. A general notice board will be erected at the site entrance. This will also be in the appropriate official languages, stating the names, addresses and telephone numbers of the Permit Holder and the Responsible Person, the hours of operation, and an emergency telephone number. The sign will clearly state the class of landfill and the types of waste that can be accepted. Wastes that cannot be accepted shall also be stated. It will be stated that disposal of non-acceptable waste types is illegal and can lead to prosecution. Clearly visible signposts warning of the associated hazards shall be erected along the fence line at intervals not exceeding 100m.

Road access to the site will be maintained at all times, in a manner suitable to accommodate the vehicles normally expected to utilise the facility. All roads, particularly on-site roads, will be so surfaced and maintained as to ensure that waste can reach the working face with the minimum of inconvenience in all weather conditions. Two-way traffic will also be possible in all weather conditions. Non-surfaced roads will be regularly graded and watered to control dust. No mud from the site will be allowed to track onto public roads.

3B-7.6 Other Elements of the Operation

3B-7.6.1 Additional excavation for cover

Sufficient material shall be excavated and stockpiled for cover material in the landfill. Where cover is however still required to be excavated on site, the Responsible Person will obtain approval from MICOA for such operation prior to any execution. Where permission is granted he will ensure that the separation between the floor of the excavation and the wet season high elevation of the ground water, as specified in the design, is maintained. Excavations shall also be properly drained to avoid ponding of accumulated surface water.

3B-7.6.2 Control of nuisances

Nuisances resulting from the landfill operation should be controlled as follows:

3B-7.6.2.1 Burning of waste

No burning of any product shall be allowed on site as this will place the entire facility at risk. Accidental fires on landfills where burning is not permitted must be extinguished immediately.

At this hazardous waste landfill site a major fire may be classified as major incident in terms of the Major Hazard Installation Regulations governed under the Occupational Health and Safety Act. The employer shall therefore implement all items of these regulations, which include among others a risk assessment and development of on-site and off-site emergency plans. The risk assessment shall include studies on dispersion of possible hazardous combustion products and on-site and off-site exposure levels.

3B-7.6.2.2 Litter

Windblown litter shall be picked up and removed from fences and vegetation on a daily basis.

3B-7.6.2.3 Odours

Odours shall be combated by good cover application and maintenance. Furthermore, the prompt covering of malodorous waste to reduce odour problems is a minimum requirement. In extreme cases, odour suppressants such as spray curtains may be required. Where breaches in the cover from which significant volumes of landfill gas escape are identified by their odour, proper investigation shall be carried out as to the cause and remedial actions shall be taken.

3B-7.6.2.4 Dust

Unsurfaced roads and ungrassed or unpaved areas, which give rise to dust problems, will be regularly watered to restrict dust to levels which do not pose a nuisance to workers or users of the facility.

3B-7.7 Gas management of atmospheric emissions from the landfill, delivery vehicles and on-site plant

No gas management systems will be installed on site. However, where gas is detected through required routine inspections the required procedures and systems will be correctly operated, maintained and monitored to ensure that any gas emanating from the site is properly managed and curtailed.

Where gas is detected from the landfill the Responsible Person shall be informed to determine the exact source and to take the necessary steps to kerb the further generation of gas.

Where gas is generated by vehicle and on-site plant the vehicles and plant shall be serviced and maintained in such condition to ensure the minimum emissions of gas. Vehicles and

plant shall be monitored regularly by the Responsible Person and the condition of such vehicles and plant shall be reported to the EO on a monthly basis.

3B-7.8 Noise pollution and abatement

All equipment used on site shall conform to the local authority's by-laws concerning noise levels and hours of operation. In the absence of by-laws, national regulations on noise control shall be complied with.

Noise will be generated during the operational phase by activities on site, plant and heavy machinery, delivery traffic and peripheral noise such as shift sirens. The blending and landfill plant will be the main source of noise pollution on site. Means of reducing noise emissions and the impact of noise will include performing regular maintenance on all operations vehicles and installing bafflers on vehicles. The contractor will ensure that all vehicles brought to site are within noise emission standards and that they remain that way throughout the contract.

Machine working hours will be restricted between 07:00 and 17:00. Permission to operate outside these hours must be obtained from the EO. Sirens, hooters, alarms and other inherently intrusive noises must be removed or be altered so as not to be audible over any significant distance from the site, where not required.

Personnel must be informed about the importance of noise restrictions and trained in methods of implementing these strategies.

3B-7.9 Leachate (collection and treatment systems)

The treatment of leachate or contaminated water on the site will be mandatory prior to discharging it back into the environment. As with the drainage system, the leachate management system shall be maintained and continuously adapted and developed, as the landfill develops. Where treatment is involved, a whole separate operating procedure shall also be adhered to. This procedure will be written up in the Operating Plan.

3B-7.10 Groundwater pollution monitoring and control

The facilities provided are aimed at kerbing the pollution of groundwater that could arise from the disposal of waste in the area. The major barrier against groundwater pollution is the landfill liner. Everything possible shall be done to ensure the liner system provided at the base of the landfill is not breached or damaged. The operations inside the landfill shall be monitored carefully and specifically by the Responsible Person to ensure no damage is caused to the entire composite liner system. Daily inspections shall be carried out to locate any possible damage. Should such damaged area be located all activities shall be diverted from the area until the damaged section is reinstated and checked. MICOA shall also be informed of the damage to the liner thus incurred.

All drainage systems on site shall against malfunctioning. Any malfunctioning or damage shall be reported to the Responsible Person who shall ensure that tha drainage systems are repaired or reinstated.

Any spillage of waste on or off site shall be dealt with in accordance with the emergency procedures to clean up the spillage.

The possibility for any pollution of the groundwater will be monitored by taking water samples from the dedicated monitoring boreholes. Such samples of water obtained from the boreholes will be analysed to determine the change in the water quality compared against the baseline information. The Responsible Person shall ensure that the monitoring boreholes are always protected, visible and accessible and that the sealed lids of the boreholes are not tampered with.

ISOTOPE MONITORING

The environmental isotopes species required to be monitored in this study are the non-radioactive (or "stable") isotopes Oxygen-18 (^{18}O) and Deuterium (^{2}H) as well as the radioactive isotope ^{3}H which label the water molecule itself. Isotope analyses can be performed at the Schonland Research Centre of the University of the Witwatersrand in South Africa.

The Stable Isotopes – Oxygen-18 and Deuterium

The concentration of these isotopes can only be changed by physical processes such as evaporation and can therefore be used as a detector of evaporated leachate in the monitoring boreholes. (See Appended notes on stable isotopes)

A 100ml untreated sample is required for stable isotope analysis.

Sampling must be done as frequent as that recommended for chemical analysis. Base line analysis must be done before commissioning of the site.

Tritium Isotope

This isotope is radioactive with a half-life of 12.43 years. It is recorded in TU (Tritium Units). The tritium content gives an indication of recharge to the monitored aquifer and therefore its usefulness as a monitoring borehole. As a result of artificial tritium present in leachates, the tritium can be used as a unique tracer of leakage from the leachate pond to the monitoring borehole. (See the Annexure 1 paper by Levin and Verhagen (2000) on the topic)

A 1 liter untreated sample is required for tritium analysis. The tritium analysis must be conducted before commissioning, as the frequency of future monitoring of each borehole will be recommended from the determined tritium content.

3B-7.11 Resource and energy usage management including potable water and electricity usage

The use of energy and resources such as potable water shall be done sparingly. All machinery shall be set to operate optimally. Electricity consuming utilities shall be checked for damage or malfunctioning and repaired or replaced to ensure minimal use of electicity. The use of resources shall be monitored and managed by taking daily records of consumption to assist in setting trends and to determine the optimal consumption levels.

3B-7.12 Emergency procedures regarding hazardous waste spills management

In the event of a spill of hazardous waste the spillage shall be confined to the smallest area possible to ensure no further unnecessary pollution of the environment. The Responsible Person shall be informed immediately of the spillage and the spillage shall be cleared as per the approved action plan for such events. Every precaution shall be taken to ensure no harm comes to the specifically and trained personnel dealing with the cleanup operation. The area of spillage shall be rehabilitated as per the rehabilitation of disturbed areas once the spillage has been cleared.

3B-7.13 Emergency procedures regarding vehicle, plant or equipment spilling of fuel or lubricants

This section covers the reaction procedures pertaining to minor and major spills of fuels, lubricants or any other contaminants on the construction site.

3B-7.13.1 Minor spills

If a minor spill of fuel or oil on an area that is not bunded, or does not drain into an oil skimming facility, is detected early enough and treated with suitable absorbent material, soil contamination can be averted. However, if soil contamination is evident, the procedure stipulated below will be followed.

Recommendations for the volume or toxicity of substance spilt which will constitute an emergency (for which the procedure stipulated below will be followed), are given in Minimum Requirements for Hazardous Waste disposal.

Detailed records of all spills on the site, including nature, date and time, position, possible causes, potential environmental impact and mitigatory actions taken will be recorded by the contractor and submitted to the EO for follow-up.

3B-7.13.2 Major Spills

Any soil contaminated by a significant spill of fuel or other contaminant outside the bunded area will be removed and taken to the landfill or alternative approved by the EO according to the nature and level of contamination. All removed soil will be replaced with clean imported topsoil and the area re-vegetated as soon as practicable. Recommendations for the volume or toxicity of substance spilt which will constitute an emergency are given in the Minimum Requirements for Hazardous Waste disposal. The spill will be addressed by firstly containing it if possible to minimise the environmental impact. The environmental impact of an incident or accident is to be determined, also including the possible cause of the spill, recorded and appropriate mitigation or rehabilitation proposed. The proper execution of the rehabilitation work is to be done whilst complying to all relevant local and international safety precautions.

Major spills on the paved areas must be contained on the paved area and pumped into a suitable container.

There must be proper protective equipment for, and training in, the handling of spilt hazardous substances for personnel dealing with spills or leaks as well as first aid available.

Detailed records of all major spills on the waste disposal site, including nature, date and time, position, possible causes, potential environmental impact and mitigatory actions taken will be recorded by the contractor and submitted to the EO for follow-up. If possible, photos will be taken of major spills.

3B-7.14 Emergency procedures regarding fire or explosions

Prior to operations at the site the contractor shall submit an emergency procedures plan with specific attention to the possibility of fire or explosions at the facility.

The temporary waste storage facility will be provided with suitable fire prevention and protection equipment, involving automatic alarms, appropriate fire control equipment and trained personnel. Firewater runoff will be contained within the contaminated water pond.

Provision shall be made for special dry foam extinguishers for water-reactive hazardous waste streams.

An emergency plan is to be developed that takes into account the types of hazardous wastes allowed on site and if necessary stored and the types of packaging material used. These include:

- The flammability of the hazardous waste stored
- The combustibility of the packaging material used
- The quantity of the waste
- The toxicity or other hazardous properties of the waste
- The combination of types of waste stored
- Safety and health precautions required by all staff on site

3B-7.15 Hazardous waste transportation routes and handling procedures

The transportation routes used by the transporter of the hazardous waste that is to be disposed at the hazardous waste landfill site shall be approved by MICOA. The handling procedures shall be as follows:

- **Identification of waste.** The transporter shall be provided with accurate information about the nature and properties of the load.
- **Documentation.** The transport operator shall be provided with the relevant transportation documentation for the consignment.
- **Security of load.** The load shall be properly loaded and secured on site.
- **Hazchem placard.** The transport operator shall be supplied with the appropriate Hazchem placards.
- **Hazchem placard** The transport operator shall ensure that the Hazchem placards are properly fitted to the vehicle.

- **Vehicle Roadworthiness.** The Responsible Person shall ensure that before the vehicle leaves the consignor's premises it is not overloaded or showing any obvious defect that would affect its safety.
- **Escape of hazardous spillage at site.** The Department and the Local Authority shall be advised immediately, should it prove impossible to contain spillage of a Hazardous Waste on a site.
- **Protection against effect of accident.** The Generator - or his representative, i.e., transporter - shall ensure that adequate steps are taken to minimise the effect an accident or incident may have on the public and on the environment.
- **Spillage on site.** The Generator shall initiate remedial action to clean up any spillage remaining on a site after an accident.
- **Notification.** All road accidents shall be reported to the Department of Transport on the prescribed documentation.
- **Notification** In case of an accident, a full report, containing all the relevant information such as waste transported, generator, location of accident, incident, date, time, condition of road, weather, etc. shall be sent to MICOA.

3B-7.15.1 Temporary storage and accumulation

Waste shall not be stored on a temporary basis for more than 90 days. A Generator may accumulate the following quantities of Hazardous Waste on site for 90 days or less without a permit for a waste disposal site:

Hazard Rating 1 = 10 kgs
Hazard Rating 2 = 100 kgs
Hazard Rating 3 = 1 000 kgs
Hazard Rating 4 = 10 000 kgs

provided that:

- the waste is stored in such a manner that no pollution of the environment occurs at any time;
- the date upon which accumulation begins is clearly marked and visible for inspection on each container;
- while being stored on site, each container and tank is labelled or marked clearly with the words "Hazardous Waste";
- the storage area shall be clearly labled with a weatherproof, durable and clearly legible notice-board in official languages at every entrance of the storage area with the words "Hazardous Waste: unauthorised entry prohibited".

3B-7.15.2 Transport

If there is a transport accident resulting in leakage or spillage of the Hazardous Waste, two distinct actions are required, i.e.,

- Emergency action shall be taken to contain the spilled material and to prevent further uncontrolled spillage or leakage. In addition immediate steps shall be instituted to clear the road from any material that may delay or stop the traffic.

- Remedial action shall be taken to clean up and remove any spillage or residue and to ensure that no environmental pollution or contamination of water resources will take place at a later stage. The load must be properly loaded and secured on site.

These requirements shall be made known to all the users of the waste disposal facility.

3B-7.15.2.1 Emergency Action

If a road accident causes leakage or spillage of Hazardous Waste, the driver of the vehicle shall immediately notify the local emergency services of the incident, clearly stating:
the location;

- the nature of the load being carried; and
- the status at the site of the accident itself, i.e., whether further leakage is still taking place, whether the vehicle or the load is on fire and what the traffic situation is.

Until assistance arrives, the driver will be responsible for warning and if necessary regulating traffic. Bystanders must, under all circumstances, be kept away from the vehicle and its load.

The Transport Emergency Card (Tremcard), which must accompany the load, must be recovered from the vehicle and handed to the Police and/or emergency personnel on their arrival. The Tremcard information on emergency action and the HAZCHEM placard on the vehicle will provide the emergency services with the initial information required for action.

Since spillages of Hazardous Waste resulting from road accidents or failure of the containers normally happen outside the Generator's premises, arrangements shall be made beforehand for good and prompt communication between the carrying vehicle and the Generator of the waste. When such an incident is reported the Generator shall promptly inform the Regional Office of the MICOA. In addition, the Generator must ensure that all technical information relating to the waste material is made available immediately to emergency teams on the site of the incident.

It should be noted that the Generator - or his representative, i.e., transporter - retains primary responsibility for ensuring that adequate steps are taken to minimise the effect of an accident or incident on the public and on the environment.

If there is a serious accident that results in substantial losses or consequential damage, it is advisable that the Generator should also advise its insurance company since they may wish to send an assessor to conduct an on-site inspection.

3B-7.15.2.2 Remedial action

Remedial action to clean up any spillage remaining on site after an accident has to be initiated by the Generator. Such remedial action may be undertaken by the Generator himself, a waste disposal contractor appointed by either the Generator or by the insurance company or, if this fails, by the State.

In such event all costs relating to the remedial action will be recovered by the State from the Generator of the waste. The remedial action will depend on the nature and properties of the waste material, on the physical environment in which it has been spilled and on the severity of the spillage. In some instances washing away of residues with water may prove adequate but in other instances chemical treatment of the residue or even digging up of soil and removal thereof to a disposal site may be required.

The major objective of the clean-up procedure shall be to minimise the risk of contaminating the environment and in particular the water sources at a later stage.

3B-7.15.2.3 Reporting of road accidents and spillage

All road accidents must be reported to the Department of Transport on the prescribed documentation. In addition, an incident report must be compiled, giving full details of the nature of the incident, amounts of waste material lost and remedial action taken to prevent environmental and water pollution.

3B-7.16 Fuel and lubricant storage facilities

All aboveground petroleum product (diesel, oil and petrol) storage tanks shall have a concrete platform. In the event of a spill, pumping of the product, either for recovery or for disposal must be done as quickly as possible to reduce the amount of vapours being released into the environment. All drainage from fuel storage areas shall be diverted to the settling ponds.

3B-7.17 Faunal and floral management on site, including birds and mammals and invasive alien vegetation species

Natural vegetation shall be kept in as undisturbed a state as possible. Special attention shall be paid to preserve large trees and plant communities such as wetlands, sponges, forest of any sort and riparian vegetation. Indigenous plants or wild animals (including reptiles, amphibians or birds etc.) may not be damaged or harmed, excluding vegetation removals as part of the development requirements. All incidents of harm to any animal or natural vegetation (apart from the agreed areas) must be reported to the EO.

Local communities must be given the option of using any plants of medicinal value. Specimens must not, however, be given away for any other use e.g. firewood, structural purposes. The ECO will oversee the distribution of these plants. All remaining plants must be used in the rehabilitation phase and will be kept in a site nursery for this purpose.

The works shall be cleared of alien vegetation as identified by the EO. Labour intensive methods shall be used as far as possible. Clearing of alien species should, as far a possible, be done during the months of the year in which the plant is not in seed. This will prevent inadvertent spreading of seed. An effort must be made to remove the entire root system where after the plant shall be left to dry out on a hard surface that will not facilitate the germination of seed.

3B-7.18 Encapsulation procedures

The Mavoca Landfill facility is designed and based on the principle of neutralisation of the hazardous material through a blending process. The procedure of encapsulation is therefore not permitted at the landfill without the specific approval approval of MICOA.

3B-7.19 Storm water management and drainage

3B-7.19.1 Drainage

The principles of drainage on and around the landfill site are as follows and shall be adhered to:

- Upslope run-off water shall be diverted away from the waste, to prevent water contamination and to minimise leachate generation.
- Where contaminated water or leachate does arise on the site, it shall be managed. This means that it shall be kept out of the environment. This also applies to the drainage from wash bays and the blending facilities.
- Clean, uncontaminated run-off water shall not be permitted to mix with, and increase the volume of, contaminated water. The principles of the main drainage system are presented in the site design.

All upslope cut-off and toe drains, will be in place before the landfill is commissioned.

The following are minimum requirements and shall be adhered to:

- Run-off and storm water will always be diverted around one or both sides of the waste body, by a system of berms and/or cutoff drains.
- Water contaminated by contact with waste, as well as leachate, will be contained within the site. If it is to be permitted to enter the environment, it shall conform or be treated so as to conform to the Mozambique Effluent Standards.
- The water in the cells will drain away from the deposited waste. The resulting contaminated water, together with all other contaminated run-off arising from the landfill, will be stored in a retention dam. It will be pumped from the dam back onto the landfill in order to evaporate. The water that has remained in the dam will be allowed to evaporate or be treated prior to being disposed of if it conforms to the Effluent Standards.
- A 0,5m freeboard, designed for the 1 in 50 year flood event, shall always be maintained in the contaminated water impoundments.
- All temporarily and finally covered areas shall be graded and maintained to promote run-off without excessive erosion and to eliminate ponding or standing water.
- Clean, uncontaminated water, which has not been in contact with the waste, shall be allowed to flow off the site into the natural drainage system, under controlled conditions.
- All drains will be maintained. This involves ensuring that they are not blocked by silt or vegetation.

3B-7.19.2 Storm water management

Drainage / contaminated storm water other than the leachate from the landfill or blending areas shall flow into a settling pond with a minimum detention period of 10 days. The purpose of the settling ponds is the temporary detention of contaminated water prior to discharge into a natural watercourse to prevent siltation. No petroleum products shall be allowed to pass into the settling ponds, by providing suitable oil-skimming facilities. Settling ponds shall be sized by the contractor for approval by the EO.

Natural surface flow of uncontaminated storm water across the landfill site shall be separated from the drainage channelled into the settling ponds. This shall be achieved by instituting diversion berms and drains to deflect run-off from these structures.

All water released from the settling ponds shall be evenly dispersed through, and over grasslands to filter the silt-laden water (no channel to be constructed). At least 90% grass cover of minimum height 150mm shall occupy the land down-slope of the discharge area.

3B-7.19.3 Erosion Protection

The Contractor shall take appropriate and active measures to prevent erosion resulting from his own works, operations and activities as well as storm water control measures to the satisfaction of the EO. Restoration costs are likely to be for the contractor's account, should these measures not be reasonably implemented. Other measures as may be necessary shall be taken to prevent the surface water from being concentrated in the wetland, streams or dams and from scouring the slopes, banks or other areas. All such measures must be discussed with and approved by the EO. Measures can include cut off trenches, straw stabilising, brush packing etc. A method statement is required from the Contractor prior to site commencing operations.

3B-7.20 Landscape design maintenance, including the use of fertilisers, insecticides, planting material and erosion control

All planted areas will be maintained in a weed-free condition by hand. The beds will be kept in a tidy condition. The maintenance contractor will allow for checking the stakes and pruning as required.

All grassed, planted and hydroseeded areas will be adequately watered at frequent and regular intervals in order to ensure proper germination and growth until an acceptable cover has been established and thereafter until the beginning of the maintenance period. Where hydroseeding is carried out, the commencement of watering may be postponed until a favourable time of the year but watering should commence and continue as soon as the seeds have germinated and growth begins.

3B-7.20.1 Use of Fertilisers

All fertiliser shall be stored in plastic bags. Fertiliser mixtures used shall comply with the specification in Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act (Act No 36 of 1947).

During the process of rotavation, substances which need to be added in large quantities will be thoroughly mixed throughout the growing horizon to a depth of 300 mm and not just placed on the surface. These substances include lime, phosphates, manure, compost, slow release fertilisers, colloids, etc. All soluble fertiliser will be strewn on the final layer before final finishing is commenced, and worked into the top 150 mm soil in grass areas. No fertiliser will be added more than two weeks prior to planting.

The fertiliser recommendations below are general recommendations only because certain plants have specific nutrient requirements. Furthermore, the disturbed nature of the soils and variability in nutrients status warrant only generalised recommendations. All considerations taken into account, it is judged that agricultural gypsum will be applied as soil ameliorant. This procedure will be monitored on a yearly basis by means of samples taken from predetermined sample points.

Prepare a topsoil mixture that consists of 8 parts per volume topsoil, 2 parts well decomposed compost, 1 kg/md superphosphate fertilizer and 1 kg/md 2:3:2 mixture fertilizer, 0,5 kg hoof and horn/m3 or soil amendments as recommended according to submitted chemical analysis.

Topsoil should be neither extremely acid nor alkaline. The pH should be in the range of 6 to 7.

3B-7.20.2 Use of Insecticides

The use of insecticides on the landfill site will be minimised to the absolute essential. All insecticides will be applied strictly as per the manufacturer's guidelines by trained contractors or staff that is suitably equipped with protective clothing. Care will be taken not to spill undiluted insecticides on the site. Bio-degradable, selective insecticides are preferred.

3B-7.20.3 Plant Material and Planting Procedure

If the planting of additional vegetation is required during the operations and rehabilitation period, the choice of plants will match the existing landscape design. The planting procedure proposed for the landscape plan will be followed.

3B-7.21 Facilities management and maintenance, including maintenance of equipment and structures

Adequate facilities, equipment and suitably trained staff will be provided and employed in order to ensure an ongoing environmentally acceptable waste disposal operation.

3B-7.21.1 Infrastructure

An on-site laboratory is provided with the facility to ensure proper and adequate functioning of the facility. All incoming waste will be analysed at the laboratory and strict laboratory procedures will be adhered to.

3B-7.21.2 Plant and equipment

The plant and equipment on site will be commensurate with the size and type of the operation. The type of equipment employed for all phases of the operation will therefore be of suitable capacity and construction. The site will have a combination of purpose-built landfill compactors, bulldozers, front-end loaders and trucks to transport cover material.

It will be required of the operator to provide sufficient suitable equipment, drivers and back-up to ensure environmentally acceptable waste disposal at all times. The plant and equipment shall provide the means whereby the waste can be disposed of in accordance with the Operating Plan as well as the Environmental Management Plan. It shall also be maintained in good order, so as not to cause nuisances such as noise and air pollution. No vehicle shall be allowed to leak oil or any petroleum product and shall be rectified as soon as such occurrence is detected.

3B-7.21.3 Staff

It will be required that the operation of the landfill site be carried out under the direction of a Responsible Person. Due to the waste disposal site being classified a **H:H** site, the Responsible Person shall have the academic equivalent of a BSc Degree with a Chemistry major and suitable experience. He/she shall also be fully *au fait* with the Hazard Rating system and its application.

The Responsible Person shall, in all cases, be supported by suitably qualified and competent staff. This staff complement shall be commensurate with the size and type of the operation, as well as with the facilities and plant involved. Sufficiently qualified staff and back-up will be required to ensure that the operational and environmental requirements relating to the operation are met. Where applicable, the Responsible Person shall also ensure that the requirements of the Occupational Health and Safety Act are met, with regard to visitors and site staff.

3B-7.22 Servicing and washing of vehicles and plant

All vehicles and plant shall be maintained to ensure that there are no leakages. All contaminated surfaces, especially compacted subgrade, shall be removed from site.

A dedicated vehicle wash bay shall be created. The wash bay shall be upon a screed platform to prevent erosion and infiltration of the pollutants into the ground water. All run-off from the platform shall be contained by bund walls. The wash water should be directed via a lined channel to a settling pond. The contractor shall provide and maintain bund walls around the wash bay within the site. Where the drain passes through or across the bund wall the contractor shall provide a means of preventing flow so that in the event of a leak all liquids can be contained by the bund walls.

A dedicated vehicle service area shall be created. Minor services will be allowed on the service area. Soil severely contaminated by oil, fuel or chemical leakages shall be removed

and disposed of at a site identified by the RE. All major servicing of plant and vehicles will be done off site, at the contractor's premises.

All used oil shall be retained and disposed of by removal for recycling at an urban centre or disposal in any other manner approved by the ECO. The contractor shall educate workers on the appropriate methods for workshop maintenance and fuel points to prevent fuel and oil being washed out of containment areas.

The contractor will provide a concave concrete floor slab to prevent erosion and infiltration of the ground water by petroleum products. The slab shall drain into the temporary oil skimming tank. The contractor shall provide bunded walls around the maintenance area. Where the drain passes through or across the bund wall the contractor shall provide a means of preventing flow so that in event of a leak or overflow from the skimming tanks all liquids can be contained by the bund walls.

All major spillage of oil onto concrete surfaces shall be controlled by the use of an approved absorbent material such as Ociansorb, Drizit or similar.

3B-7.23 Control of access and visitors

3B-7.23.1 Access control

In order to facilitate the above waste acceptance procedures, access to the site will be controlled. The vehicle access to a site will be limited to a single controlled entrance, to prevent the unauthorised entry and illegal dumping of waste on the site. The site entrance will comprise a lockable gate which shall be manned during hours of operation. Additional security, after operating hours, will be provided at the hazardous waste disposal. In addition to the gate, the site will have the portion of the site currently in use adequately fenced and/or secured. The fences will be at least 1,8m with an overhang and will be constructed of galvanised steel wire, or of other suitably sturdy and durable material. All site boundaries will be clearly demarcated and measures shall be taken to prevent unauthorised vehicle access.

3B-7.23.1.1 Records

Accurate and comprehensive records as per the operating plan shall be kept of all waste entering the site. Details of waste category, quantities and origin will be obtained and recorded for all wastes accepted by the Contractor's access controller at the gate. A daily summary of the wastes accepted shall be recorded by the Contractor in the Daily Diary in the Contractor's site office.

The Contractor will record all relevant details of any person, vehicle or operator who attempts to bring any unacceptable waste onto the site and shall advise such person or Contractor of the site of the nearest facility where such waste can be safely handled. In no instance may such wastes be allowed on site.

3B-7.23.2 Times of Operation

The landfill site shall be open to accept waste from Monday to Friday during normal working hours, throughout the year, including all public holidays. In the event that waste needs to be disposed of over a weekend, provision needs to be made and security and the weighbridge operator contacted. Landfilling will only be carried out during daylight hours. Before the landfill is opened for operation or after the landfill has been closed, the Contractor can use this time for preparation work, rehabilitation work and cleaning of the site.

3B-7.23.3 Security

There are a number of aspects related to security with regard to a hazardous waste landfill. Security services need to be in place for a number of reasons:

- To control the access for safety reasons
- To prevent unauthorised pedestrian access and hence prevent waste reclamation and squatting taking place.
- Prevent criminal elements from entering the landfill site.

Infrastructure needs to be put in place to limit access, to secure the area and thereby limit liability. A 1.8m high fence should be erected around the site and leachate dams, and a lockable gate. Lights should be provided around the site, especially at critical areas such as the weighbridge, office block, workshop and waste stabilisation area, and at the cell where operation is taking place.

A good communication link should be set up between all guards. Any incident on site, such as theft, fires, illegal access should be reported and emergency services contacted. Records should be kept of all incidents, including time, place, type of incidents, etc.

A detailed list of contact details for the security company and Contractor on site should be visible and easily accessible.

3B-7.23.4 Collection of disposal tariffs

In order to offset the development costs of the hazardous waste disposal facility, waste disposal tariffs shall be levied and collected. Tariffs will be displayed on the notice board. They shall be based on mass.

3B-7.23.5 Security

In addition to access control, suitable security will be provided to protect any facilities and plant on site. Unauthorised pedestrian access will be strictly prohibited at the hazardous waste disposal site. Where the fencing is found to be in-effective, additional measures shall be taken to secure the site.

3B-7.24 Personnel education (basic do's and don'ts) and behaviour

Working hours will be agreed upon with the affected communities prior to construction.

Cooking facilities shall be provided for the construction staff within the confines of construction camps. No trees or natural vegetation shall be removed for the making of fires. No fires shall be permitted, unless a specifically designated area has been identified and set aside by the RE for that purpose. Where there is a particular fire hazard at any point in the construction works the contractor shall ensure that his employees are properly trained in the use of the appropriate fire fighting equipment and that such equipment is on hand at all times.

The contractor shall take all measures necessary to prevent his staff from hunting, capturing or destroying animals and birds in the vicinity of the construction camp. The contractor shall take all necessary precautions against trespassing on adjoining properties and shall take care that all livestock, game or vegetation are not interfered with.

The contractor shall ensure that suitable safety regulations and precautions are established and brought to the attention of the personnel. Construction hats and other protective clothing shall be worn at all times whilst on site. The contractor shall comply with all safety regulations regarding the electricity supply and he shall take every precaution to ensure the safety of all the people on site.

The contractor shall ensure that as far as practicable, suitable arrangements are made on site for the maintenance of health, the prevention and overcoming of outbreaks of disease and of adequate first aid services.

The contractor shall be responsible for his own security arrangements and shall comply with any security instructions which the Engineer may issue from time to time.

The contractor shall, at his own cost, provide for a constant supply of potable water for human consumption to the site offices and other domestic use on site. The contractor shall allow for chemical testing of water samples on a monthly basis.

The contractor shall ensure that his personnel are educated and informed as to the requirements of the EMP. A copy of the EMP must be kept on site. The contractor shall endeavour to ensure that his staff complies with the EMP requirements for best practice as described by this document.

Section 3B-8 Monitoring and Auditing During Operational Phase

3B-8.1 Introduction

The general objective of landfill operation monitoring is to verify that the landfill conforms to the required standards and the site Permit conditions. More specific objectives are:

- To ensure that the accepted site design is properly implemented.
- To function as a control measure to ensure that the operation conforms to the required standards.
- To quantify any effect that the operation has on the environment, and, in particular, any effect on the water regime.
- To serve as an early warning system, so that any problems that arise can be *timeously* identified and rectified.

They might include the proper compaction and covering of waste, the integrity of drainage systems and the consideration of site impact.

Monitoring serves to quantify any effect of the operation on the environment, especially the water regime, and act as an early warning system, so that any problems that arise can be identified and rectified. Such problems would include malfunctioning drainage systems, cracks in the cover, leaking liners, and ground or surface water pollution. Any problems identified must be rectified as soon as possible. In addition, monitoring serves as a performance indicator, and hence as a control or management tool, for the landfill operator.

In this context, monitoring is a general term used as described above. Monitoring may be carried out by means of site inspections or audits, data collection, sampling, analysis and interpretation. It also involves monitoring the response of IAPs.

3B-8.2 Background

The disposal site shall be monitored by a Landfill Monitoring Committee which will include IAPs to identify problems and to keep the public informed of activities/developments on the landfill.

The landfill auditing will be done by MICOA or its representative to ensure that the waste is being properly disposed of.

3B-8.3 The Required Extent and Frequency of Monitoring

It will be the duty of the Responsible Person to ensure that the minimum requirements for operation monitoring are applied to a degree commensurate with this hazardous waste landfill, the situation under consideration and the risk of polluting the environment, more specifically the water regime. Monitoring will be carried out to the satisfaction of MICOA, and the Responsible Person shall be required to provide additional information. This could include detail about airspace utilisation and cover volumes used or waste stream data analyses.

3B-8.4 Landfill Site Auditing

The landfill will be audited and inspected to ensure the maintenance of acceptable standards. At this hazardous waste landfill, the audit committee shall consist of the Permit Holder, or the Responsible Person, the Department's regional or national office inspectorate and, where applicable, the relevant consultant(s). In some instances IAPs from the Landfill Monitoring Committee shall also be included. The initial frequency of the audit shall be

agreed upon by all the parties concerned, during the planning stages when the IAPs are consulted. Audits shall occur at monthly intervals for this hazardous waste site. Where problems occur, this frequency may be reviewed in consultation with MICOA and the IAPs.

General aspects of a landfill site audit will include consideration of site security, site access, condition of roads and traffic control. The actual waste deposition will be addressed in terms of cell construction, pre-treatment, waste deposition, spreading, compaction and covering. Operating procedures as specified in the Operating Plan will also be carefully appraised, as would aspects such as drainage, litter control and aesthetics. Similarly, all site specific Permit conditions and design requirements shall be addressed. Details of how such an audit is conducted are not addressed here. The audit programme shall, however, include the following:

- A checklist of items to be audited
- A report on the findings of the audit
- A record of performance.

A record of any identified problem areas and the recommended actions to rectify these problems shall be submitted to the Responsible Person for implementation. The audit results will be made available to the IAPs through Landfill Monitoring Committees, so that any problems identified can be discussed and addressed. A record of complaints received and actions taken, must also be maintained.

3B-8.5 Other Monitoring

In addition to the landfill site audit, monitoring shall comprise the collection, processing and interpretation of certain data. The required data, the format and the frequency with which it must be presented to MICOA would be specified in the Permit conditions. Most of the procedures outlined here would be included in the Operating Plan, which would also make provision for certain actions to be taken in response to any problems identified during monitoring.

3B-8.5.1 Gate or weighbridge recording procedures

Landfill site operators, facility users and the Department will all require waste disposal records for different reasons. Over and above the measurement of incoming waste for commercial purposes, records are also necessary for site management and control. Such records will obtained from record keeping at the gate or weighbridge.

The method of waste recording shall be appropriate to the nature and the volume of the wastes entering the site. Such data bases are sometimes termed 'dynamic records'. Records shall be kept of all waste entering the site. Waste will be categorised by the number of loads (defined by volume or mass), the type of waste and the source and in terms of its hazard rating. Records will be kept on both a daily and a cumulative basis. Such historically factual records are sometimes termed 'static records'. These shall be maintained and archived. With the accumulation of records, a data base will be established and maintained at the landfill site. This will be extended to the recording of the position of all hazardous waste disposed on site, on a weekly basis, in terms of both plan and elevation, i.e. in three

dimensions. In the case of the encapsulation of waste with a Hazard Rating of 1, the exact co-ordinates of the encapsulation cells shall be recorded.

3B-8.5.2 Volume surveys

Surveys shall be performed with the appropriate instruments and accuracy to determine the volume of waste disposed. The entire site will be surveyed prior to commencement of waste disposal and annually thereafter.

3B-8.5.3 Collection and processing of other data

In addition, meteorological records should be kept, including rainfall, evaporation, wind, etc. Together with records of leachate and run-off quantities, the site water balance can be calculated and management of the site water balance improved.

3B-8.5.4 Leachate and water quality monitoring

Water Quality Monitoring Plan for the Landfill Site will be required. This involves background analyses, detection monitoring, investigative monitoring and post closure monitoring. The Contractor together with MICOA will be responsible for carrying out the Water Quality Monitoring Plan.

The objectives of the water quality monitoring plans are therefore:

- To indicate any escape of leachate into the water environment and to quantify its effect.
- To serve as an early warning system, so that any pollution problems that arise can be identified and rectified.

Surface and ground water samples shall be collected and analysed for water quality parameters, as required in the document "Minimum Requirements for the Monitoring of Water at Waste Management Facilities". The water quality monitoring system therefore includes the monitoring of surface water bodies, ground water and leachate in the vicinity of the landfill site.

Hazardous waste produces a number of defining parameters, which shall be used as detection parameters when analysing surface and ground water samples. In particular analysis shall always be undertaken for pH, Electrical Conductivity (EC), Chemical Oxygen Demand (COD), Total Organic Carbons (TOCs), Volatile Organic Carbons (VOCs), Fluorides and Heavy metals. In addition, the sampling criteria listed in the license conditions for the site shall also be analysed for.

3B-8.5.4.1 Pre-operation Monitoring

Water quality and level monitoring will commence before the landfill operation begins and before any waste is disposed of. Monitoring has therefore started during the site investigation, when all accessible surface and ground water in the vicinity of the proposed landfill was sampled and analysed. The objective of this is to provide the pre-disposal

background or datum against which future water quality can be measured. Pre-operation monitoring sampling points will, together with any proposed monitoring points, be formalised and indicated as the monitoring systems in the site design. This would then form part of the permitting procedure. During the investigation and design stages the future monitoring systems were established and recorded. Pre-operation monitoring therefore formed the basis for water quality monitoring during the operation and even after closure.

3B-8.5.4.2 Surface water monitoring system

During the site investigation, surface water quality in any associated drainage feature shall be monitored both upstream and downstream of the proposed landfill. Sampling points shall be selected at representative, easily identified sites. While a single upstream sampling point may suffice, the size and complexity of the site, i.e. its class, will determine the number of downstream sampling points required. The sampling points upstream of the proposed landfill will provide ambient background values. The sampling points downstream of the proposed landfill will ultimately indicate any pollution resulting from the site.

3B-8.5.4.3 Ground water monitoring system

The ground water monitoring system, which comprises boreholes, as per the geohydrological report. Testing frequencies shall be as per section 3B-8.11. All monitoring results shall be incorporated in the Auditing report as reported by the EO. Specific reference is made to the *Minimum Requirements for Monitoring at Waste Management Facilities.*

3B-8.5.4.4 Leachate monitoring system

As the site under discussion is a hazardous waste disposal sites, leachate management systems are required. The leachate collection systems therefore form part of the design and provision is made for future leachate monitoring.

Parameters

For consistency and for comparative purposes, the same water quality parameters shall be analysed for in both surface and ground water monitoring.

Parameters for Background and Investigative Monitoring
Ammonia (NH3 as N)
Electrical Conductivity (EC)
Alkalinity (Total Alkalinity)
Free and Saline Ammonia as N (NH4-N)
Lead (Pb)
Magnesium (Mg)
Boron (B)
Mercury (Hg)
Cadmium (Cd)
Nitrate (as N) (NO3-N)
Calcium (Ca)

pH
Chemical Oxygen Demand (COD)
Phenolic Compounds (Phen)
Chloride (Cl)
Potassium (K)
Chromium (Hexavalent) (Cr6+)
Sodium (Na)
Chromium (Total) (Cr)
Sulphate (SO4)
Cyanide (CN)
Total Dissolved Solids (TDS)

Other parameters will, however, be added by the Responsible Person, should they become necessary at this site.

Sampling

Ground water sampling methods and the treatment and storage of samples are those advocated in the *Minimum Requirements for Monitoring at Waste Management Facilities* and those advocated by Weaver in 'Groundwater Sampling'. [Ref. Weaver, J.M.C., *Groundwater Sampling*. Water Research Commission Project No. 339 TT 54/92.] Surface water sampling methods are somewhat simpler, however, in that grab samples may be taken from the surface water sampling points.

In the case of both surface and ground water sampling, clean bottles shall be used. These should be rinsed with the sample water, prior to taking the sample. Sample treatment prior to analysis would be the same in both cases and is indicated in the above references. The analysis of the samples must be performed using an acceptable method which is to the satisfaction of MICOA.

Reporting

The ground and surface water quality results from the pre-operation monitoring, together with the annotated designs of the monitoring systems, shall be submitted to MICOA for there approval as part of the Permit Application Report, i.e. the Water Quality Monitoring Plan.

3B-8.5.4.5 Operation Monitoring

Once the landfill is operational, water monitoring for level and quality shall take place in accordance with the Permit Conditions and any subsequent requirements that MICOA may have. Operation monitoring involves monitoring the water regime in the vicinity of the landfill. This is done by means of the monitoring systems included and referred to in the Operating Plan. Monitoring shall include the sampling and analysis of surface water, ground water and leachate. The above systems may, however, have to be expanded to accommodate changed circumstances.

The impact of the landfill on water quality will be assessed by making a comparison between the pre-disposal, upgradient, or ambient background, and the down gradient concentrations

monitored. This will indicate whether there is a pollution problem due to contaminated surface water or leachate leaving the site. Where complex situations are involved, a specialist should be consulted. The methodology for sampling both surface and ground water at the operating landfill would be the same as that used during pre-operation monitoring. Operation monitoring will comprise two types of monitoring, i.e. detection monitoring and investigative monitoring.

Detection monitoring

Detection monitoring will be routine monitoring carried out every six months. The parameters used in detection monitoring are limited to indicator parameters, intended to indicate the presence of pollution, as indicated in the following table.

Parameters for Detection Monitoring

(a) Bi-annually for:
Alkalinity (Total Alkalinity)
Ammonia (NH3 - N)
Chemical Oxygen Demand (COD)
Chlorides (Cl)
Electrical Conductivity (EC)
Nitrate (NO3 - N)
pH
Potassium (K)
Total Dissolved Solids (TDS)

(b) Annually for:
Calcium (Ca)
Fluoride (F)
Magnesium (Mg)
Sodium (Na)
Sulphate (SO4)

Detection monitoring shall also include any substance that has or will be disposed of on the landfill in significant concentrations.

Investigative monitoring

If detection monitoring indicates possible pollution, with an increasing trend in the parameter concentrations with time, MICOA may require further monitoring. This will be referred to as investigative monitoring and will involve monitoring the range of parameters included in the following table together with any other parameters deemed necessary.

Suggested Parameters for Background and Investigative Monitoring

Ammonia (NH3 as N)
Electrical Conductivity (EC)
Alkalinity (Total Alkalinity)
Free and Saline Ammonia as N (NH4-N)
Lead (Pb)
Magnesium (Mg)
Boron (B)
Mercury (Hg)
Cadmium (Cd)
Nitrate (as N) (NO3-N)
Calcium (Ca)
pH
Chemical Oxygen Demand (COD)
Phenolic Compounds (Phen)
Chloride (Cl)
Potassium (K)
Chromium (Hexavalent) (Cr6+)
Sodium (Na)
Chromium (Total) (Cr)
Sulphate (SO4)
Cyanide (CN)
Total Dissolved Solids (TDS)

The sampling interval in the case of investigative monitoring shall generally be monthly, or as determined by MICOA. Investigative monitoring may be enhanced by tracer or isotope studies, and the interpretation of water quality monitoring results may be enhanced by the use of Piper or Durov Diagrams. (See *Minimum Requirements for Monitoring at Waste Management Facilities.*)

Leachate

Leachate shall be sampled from the appropriate places in the leachate collection system. Sampling frequency and the parameters tested for shall be the same as for surface and ground water monitoring unless otherwise stipulated by MICOA.

Reporting

The above analyses must be presented in the format stipulated in the Site Permit, and the Permit Holder must maintain records of all analyses undertaken.

3B-8.5.4.6 Public Participation

The results of the water quality monitoring results must be available for scrutiny by the Monitoring Committee.

3B-8.5.5 Health of workers

In terms of the Occupational Health and Safety Act, the Employer is responsible for the health and safety of the people under his or her jurisdiction. The Responsible Person shall therefore use his or her discretion in applying the Act and monitoring the health of workers. This will involve medical examinations.

3B-8.6 Environmental management committee

An environmental management committee is to be established for the operations phase of the project. This committee could comprise

- The Responsible Person
- Representative(s) of the contractor
- Representative(s) of MICOA
- The EO
- An Environmental Auditor
- Representative(s) of the local community

In addition to the responsibilities of the Responsible Person and EO detailed in this report, the various members of this committee will have the administrative responsibilities tabulated below.

Member	Responsibility
Resident Engineer (Chairman)	Liaison between Contractor and all other parties
Contractor's representative(s)	Assisting in evaluation of operations/monitoring methods Assisting the EO with testing and monitoring (as detailed in Weekly Report below) where required
MICOA representative(s)	**Confirming compliance with environmental policy and legislation on site** Liaison with MICOA
EO	Compiling of monthly and non-conformance reports Conducting of pollution monitoring and monitoring as per this EMP Liaison with MICOA To take minutes of the environmental management committee meeting
Environmental Auditor	Reporting on auditing of EMP implementation. Provide guidance on EMP monitoring on site by the EO Act as external advisor if required
Representative(s) of the local community	Liaison with the local community

3B-8.7 Reporting and meeting requirements

Monthly meetings should be held involving all the members of the committee, with the exception of the external auditor who will attend only to report back after an audit, or if specifically requested to attend. The purposes of the meeting shall be

- To establish the suitability of the Contractor's methods and machinery in an effort to lower the risk involved for the environment
- To discuss possible non-conformance to EMP guidelines or environmental legislation
- To assess the general state of the environment on site and discuss any environmental problems which may have materialised
- To act as a forum for input into the operation phase by the MICOA representative and external environmental auditor
- To accommodate the local community in the decision-making process regarding social and environmental issues on site

Two kinds of reports should be compiled by the EO for study by the external environmental auditor and/or MICOA:

- A monthly report which will include:

  (i) Results of any atmospheric, water or noise pollution tests performed as per this EMP in the specific month. This testing will be conducted either by an outside contractor or by the EO with equipment acquired for the project.

  (ii) A description of exceptional conditions on site whether they be meteorological, personnel related, machinery related or otherwiseA

  (iii) A description of any environmental accident or developments which could potentially develop into a non-conformance event by the contractor

  (iv) Minutes from the Environmental Management Committee meeting

- A non-conformance report which will describe, in detail, the cause, nature and effects of any environmental non-conformance by the Contractor and could stand as evidence should legal action be required. A testing sheet for atmospheric, water and noise pollution must be included for each infringement indicating the details of the event including position on site, date and time. If possible a photo should also be included in the report. This report will also suggest mitigatory measures to correct the non-conformance (if necessary) and contemplate revisions to any of the strategies used in the construction phase, whether they pertain to monitoring or to construction methods used on site.

3B-8.8 Compliance monitoring and auditing responsibilities

This section covers the monitoring and auditing requirements during the operations phase and includes sections on the environmental management committee, reporting and meeting requirements and testing frequencies.

3B-8.9 Potable water quality monitoring and treatment process, discharge water quality monitoring, air quality monitoring and noise monitoring

3B-8.9.1 Potable water quality monitoring and treatment

Water pumped from the boreholes for consumption on site shall be treated where necessary using nominal chemicals and disinfectants – sufficient to render the water quality to within the prescribed standards. The water in the storage containers or sumps shall be checked as per section 8.11 for the desired standards. Water brought to the site in a water cart shall alsobe checked for quality and the necessary treatment shall be applied when necessary.

3B-8.9.2 Discharge water quality monitoring

Uncontaminated water from discharging from site after say rain storms shall be sampled and tested for potential contamination. Should such contamination be observed the source shall be identified and the necessary steps taken to eradicated potential future contamination of the storm water run off.

Contaminated water shall not be discharged form site into the natural environment other than through attempts of evaporation. Contaminated water shall be contained in the holding ponds provided.

3B-8.9.3 Air quality monitoring

Hazardous air pollutants which could be dispersed from the landfill site as dust, or as gaseous substances will be monitored separately.

3B-8.9.3.1 Dust monitoring

Sampling of dust shall be done on site that entails sampling of dust that can be suspended, using a sampling approach that would ensure statistically that samples are representative of all possible sources of hazardous substances. Chemical analyses shall cover all substances that may be relevant to the materials and activities, using validated methods in a formal quality assurance structure. Mathematical modelling of dust released from an area source, using the source profiles of hazardous substances, shall then be conducted to provide the necessary information to assess human exposure, and health risks. The mathematical dispersion modelling has to be done at the beginning of the monitoring programme, and the model can then be used with new input data after each analytical survey. The on-site dust at the landfill site shall be characterised at least once per year, or more frequently when activities on the site may change the dust compositions.

MICOA may request analyses of dust sources, followed by mathematical dispersion modelling and human health risk assessment, at more frequent intervals if hazardous substances are present at levels that may lead to unacceptable health risks to workers or communities.

3B-8.9.3.2 Monitoring for releases of volatile substances

Direct measurement using a surface emission isolation flux chamber shall be used as the preferable technique in Mozambique to characterise area source facilities with hazardous fugitive emissions. The location and number of test points shall be adequate to enable calculation of the emission rates of substances from the total area. Sampling and analysis shall cover the complete range of substances that are relevant to the source. The data will then be used in a mathematical dispersion model to predict exposure levels for the quantification of occupational and environmental health risks. Sampling and analyses techniques shall be done by suitably qualified personnel or institutions. The frequency of sampling and analysis will depend on the level of identified risk, but shall be at least once per year when activities and waste profiles do not change. After changes that could influence the emissions profiles, measurements shall be made to establish the new profiles and associated occupational and environmental health risks.

3B-8.9.3.3 Gas monitoring

The risk of gas explosion shall therefore be continually monitored. If monitoring indicates that there is any safety risk on account of landfill gas or other gaseous compound accumulation and/or migration, controls must be considered in consultation with the MICOA. Gas monitoring systems shall be installed at the landfill facility. These shall be monitored at three monthly intervals during the operation and at the discretion of MICOA after site closure. If the soil gas concentrations exceed 1% by volume at Standard Temperature and Pressure (STP), the Department must be informed. Trained personnel shall be consulted on any level of gas concentrations.

The operating plan shall contain information regarding Methane concentration in the atmosphere inside buildings on or near the site as well as the procedures to follow in the various cases.

Apart from explosion potential, however, landfill gas also contains a wide range of volatile organic compounds that are classified as hazardous air pollutants. Where significant landfill gas is present, therefore, samples shall be taken at various positions at the landfill site, and characterised for volatile organic compounds. Sampling can be direct at gas wells, or using approved specialised techniques. The volatile organic compound compositions of the landfill gas shall then be subjected to occupational and environmental health risk assessments. This will be done at the discretion of MICOA to ensure against unacceptable health risks to workers or communities. Gas monitoring shall continue after landfill closure, until MICOA is satisfied that landfill gas no longer represents a risk.

3B-8.9.4 Noise monitoring

The Responsible Person shall continuously be observant to the generation of any unduly noise. The potential for noise emanating from any machinery or motors, such as pumps, machinery and vehicles offloading containers, shall be checked for any irregular noise. Should there be any doubt as to whether the noise experienced is outside the acceptable norm this shall be checked against the stated noise standards and reported as part of the site daily record.

Sharp noises generated by hooters or sirens will be avoided as these will travel long distances and may damage the essentially rural atmosphere of the area

Standards tests shall be performed once every two months ans shall form part of the EO report.

3B-8.10 Testing frequencies

Compliance monitoring and testing will be done as per this EMP to monitor EMP implementation and compliance and initiate corrective action if required. The EO will develop sample sheets for regular monitoring and testing, as well as establish a proper filing system for record keeping purposes.

Testing frequencies for different aspects are listed below:

- Potable water quality monitoring – every 2 weeks and more often if specific complaints are received from personnel or labourers
- Discharge water quality monitoring - every 2 weeks and more often if specific complaints are received from personnel or labourers
- Air quality monitoring – every month for the duration of operations and other dust-generating activities and when specific complaints are received from the communities surrounding the site
- Noise monitoring - every month for the duration of operations and other noise-generating activities and when specific complaints are received from the communities surrounding the site

Table 1 - Minimum monitoring requirements for the Mavoco Hazardous Waste Landfill

Monitoring requirements	Frequency
Rainfall	D
Evaporation	D
Run-off (volume, quality)	D
Water infiltration on waste	M
Toe seepage from waste	M
Soil cover on waste	M
Vegetation on waste or soil	M
Bioassaying	Y
Pressure vacuum lysimeters	M
Gas samplers	M
Electrical conductivity probes	
Leachate collectors	M
Temperature within waste	
Special detectors	M
Special monitoring holes	Yes
Other holes	Yes
Groundwater levels	M

Monitoring requirements	Frequency
Groundwater chemistry	M
Borehole yield	Y
Groundwater usage	Y
Fountain seepage	M
Water balance	Y

D = Daily, W = Weekly, M = Monthly, Y = Yearly

References

South Africa, Department of Water Affairs & Forestry, Second Edition, 1998. Waste Management Series. Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste.

South Africa, Department of Water Affairs & Forestry, Second Edition, 1998. Waste Management Series. Minimum Requirements for Waste Disposal by Landfill.

South Africa, Department of Water Affairs & Forestry, Second Edition, 1998. Waste Management Series. *Minimum Requirements for Monitoring at Waste Management Facilities.*

SECTION 3C : REHABILITATION, CLOSURE AND ON-GOING MONITORING EMP

SECTION 3C
REHABILITATION, CLOSURE AND ON-GOING MONITORING EMP

TABLE OF CONTENTS

Section 3C-1 Introduction

This section of the EMP should be read with the Mavoco Hazardous Waste Facility **Operating Plan**. It focuses on the significant issues to be addressed during the rehabilitation and closure phase and specifies monitoring and auditing criteria for this phase. It will reference certain clauses of the rehabilitation and closure plans if applicable.

Section 3C-2 Summary of project description, site description, location and layout, as well as a description of site facilities.

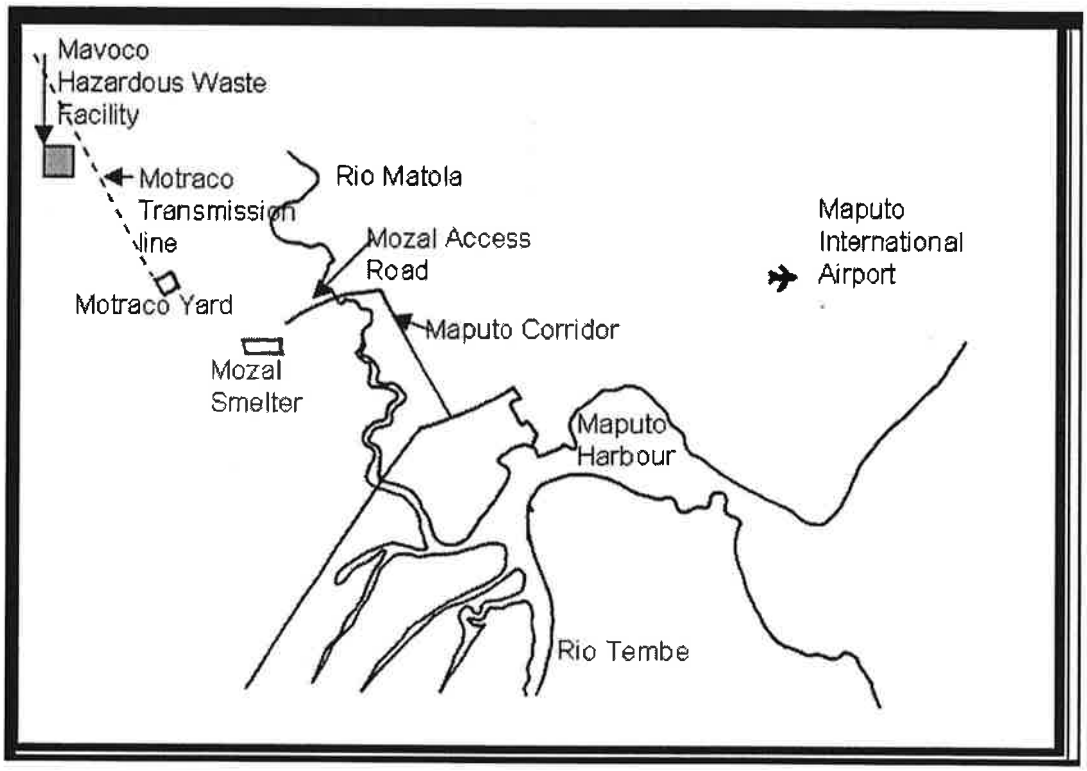
3C-2.1 Project Description

MICOA and MOZAL have a need for a hazardous waste treatment and disposal facility near Maputo for the safe disposal of Hazardous waste materials generated by the Mozal Aluminium Smelter, as well as by other industries in Mozambique. To this end MICOA, with assistance from DANIDA, a site for the development of such facility was identified.

During November 2001 the broad scope of the hazardous waste disposal facility was agreed as the design and construction of a facility that can be used to receive, characterise, record and safely dispose of hazardous waste. Supporting infrastructure required is an access road and services including water and power. The proposed facility does not include any form of waste destruction capability, but could, however, be added in future. The principle waste disposal function at the facility will be landfill and this will take on the form of dedicated lined cells that meet the requirements of H:H landfill class (High and Extreme Hazard Rating as defined in the South African Minimum Requirements). This project therefore deals with the establishment, operations and ultimately closure of an extreme and high classed hazardous waste disposal facility in Mozambique.

3C-2.2 Site location and layout

The site is located in the Beluluane area, District of Boane, approximately 10km west-north-west of the Mozal Smelter, on the south side of the Motraco power line from South Africa. The total area of the site is approximately 50ha, although only 10ha is required for the initial establishment of the facility infrastructure. The initial establishment involves a 5 year cell plus 10 year infrastructure with provision for future expansion to 20 years. The site is approximately 7,7km from the Motraco switchyard. The proposed access road mainly follows the Motraco power line



3C-2.3 Site description

The topography of the site is gently undulating, with an average slope of about 2% in a westerly direction. Elevations vary from 65m on the west side to about 80m above mean sea level on the east side of the site. Drainage is westwards towards the Rio Movene (Xingube), which flows in a southerly direction approximately 500m from the site. The Rio Movene is a seasonal stream that is dry for large periods during the year. Approximately 1km to the east of the site, there is a gentle ridge of elevation about 90m above mean sea level that forms a watershed between the Rio Movene and the Rio Matola. There is therefore a relatively small catchment area above the site. Apart from minor seasonal gulleys towards the southern and western sides of the site, there are no distinctive drainage courses on the site itself.

3C-2.4 Description of facilities on site

The main entrance to the site will be located on the north western side of the site, to link up with the planned access road running parallel to the Motraco power line. The majority of the facility infrastructure would be located on the north western side of the site.

The components of the project will comprise of the following:

- one landfill cell with operational dividing bund walls,
- a leachate buffer and management system,
- temporary waste storage system,
- access road, weighbridge,
- operational hard surfaced areas,
- storm water (contaminated and uncontaminated) management system
- administration buildings/workshops,

- laboratory,
- waste stabilisation unit,
- fire protection system,
- bore hole water supply,
- sewerage systems,
- fencing,
- power and lighting and a telephone system.

Section 3C-3 Establishing statutory and legal requirements to determine a compliance framework

An Environmental Impact Assessment (EIA) was done for the development of the facility and the access road. As part of the fulfilment of the EIA requirements of MICOA, an Environmental Management Plan (EMP) has to be prepared for the operations and management of the facility.

This EMP aims to ensure compliance to the Mozambican Statute No 48/73: Occupational Health and Safety in Industrial Premises and the Mozambican Labour Law of 20 July 1998, as well as the South African Occupational Health and Safety Act (Act No 85 of 1993) on the landfill site.

The Contractor is required to comply with all acts, regulations, bylaws standards and guidelines applicable to the nature of the work. As all parties involved with the project have in the absences of local legislation agreed to comply with the relevant South African legislation. The disposal facility operating contractor shall therefore also comply with the stated legislation which include, where applicable and as amended, but not limited to:

3C-3.1 Mozambican Legislation

- The Framework Environmental Law Act 97 of 1997

3C-3.2 South African Legislation

- The National Water Act No. 36 of 1998 – "The Minimum Requirements Series".
- The Occupational Health and Safety Act 85 of 1993.

3C-3.3 International Agreements

Both these international agreements have been signed and ratified by the Mozambique Government.

- The Bomako Convention (1991): Convention on the ban of the import into Africa and the control of transboundary movements of hazardous wastes within Africa
- The Basel Convention (1989): Convention on the control of transboundary movements of hazardous wastes and their disposal.

3C-3.4 Management Systems Requirements (ISO 14001)

The Contractor shall ensure that the site is managed in accordance with the requirements of the ISO 14001 Standard and with the Operating Manual. The Operating Manual may be amended by MICOA from time to time. Landfill audits conducted by MICOA and/or external parties will be done to ensure that legislative requirements, the ISO 14001 Standard and the Operating Manual are complied with. ISO standards that need to be complied with include:

- SABS ISO 14001 (1996): Environmental Management Systems – Specification with Guidance for Use
- SABS ISO 14004 (1996): Environmental Management Systems – General Guidelines on Principles, Systems and Supporting Techniques
- SABS ISO 14010 (1996): Guidelines for Environmental Auditing – General Principles
- SABS ISO (1996): Guidelines for Environmental Auditing – Audit procedures – Auditing of Environmental Management Systems
- SABS 0228: Identification and Classification of Dangerous Substances and Goods

Section 3C-4 Applicable standards and management criteria

The standards and management criteria applicable to this phase of the project include water quality standards for both potable water supply and effluent discharge from the site, air quality standards and noise standards. Due to the lack of local standards and the sensitivity associated with the handling and disposal of hazardous waste, accepted regional SADC standards, such as the South African SABS standards will be referenced.

3C-4.1 Water Quality Standards: Potable Water and Effluent Discharge

The acceptable levels of water quality parameters are given below. Testing will be performed either by an International Organisation for Standardisation (ISO) 9000 accredited laboratory or by an on-site laboratory, which will entail the acquisition of testing equipment. All test equipment will be calibrated every six months and records of calibration will be kept by the relevant laboratory.

The two columns on the right of the table indicate the applicable standards which will be met for potable water usage and for contaminated water / leachate release into the environment. A shaded cell indicates that the specific element will be tested for.

It must be borne in mind that this list of contaminants is by no means exhaustive. In the event of any spillage of suspected hazardous nature, the MICOA will be consulted to determine whether a more substantial list of contaminants should be tested for, based on the nature and extent of the spill.

Effluent samples will be taken according to the procedures of SABS 241.

Variable	Unit	Limit	Potable Water	Leachate/ Contaminated Water
Colour, Odour, Taste	-	Not discernible		
PH	-	6-9		
Dissolved Oxygen	Saturation	80%-120%		
Total coliforms	Counts/100ml	0-5		
Faecal coliforms	Counts/100ml	0		
Temperature change from natural water temp(point f)	°C	≤2		
COD	mg/l	75		
BOD	mg/l	10		
Total Suspended Solids	mg/l	25		
Aluminium	mg/l	≤0.005		
Ammonia	mg/l	≤0.007		
Arsenic	mg/l	≤0.01		
Asbestos	fibres/l	$\leq 1x10^6$		
Free available chlorine	mg/l	0.3-0.6		
Calcium	mg/l	16-32		
Chloride	mg/l	0-100		
Chromium(VI)	mg/l	≤0.007		
Chromium(VI)	mg/l	≤0.012		
Copper	mg/l	≤0.0003		
Cyanide	mg HCN/l	≤0.001		
Electric Conductivity	MS/m	≤70		
Endosulfan	µg/l	≤0.01		

Variable	Unit	Limit	Potable Water	Leachate/ Contaminated Water
Fluoride	mg/l	≤0.75		
Iron	mg/l	≤0.1		
Lead	mg/l	≤0.0002		
Manganese	mg/l	≤0.05		
Mercury	mg/l	≤0.001		
Nitrate	mg/l	≤6		
Nitrogen(N) (Inorganic)	mg/l	≤0.5		
Phenol	mg/l	≤1		
Phosphorous(P) (Inorganic)	N:P ratio	≤25-40:1		
Selenium	mg/l	≤0.002		
Sodium Content	mg/l	0-100		
Sulphates	mg/l	≤200		
Total Dissolved Solids	mg/l	≤450		
Turbidity	NTU	≤1		
Zinc	mg/l	≤0.002		

3C-4.2 Air Quality Standards

The likelihood of unacceptably high air pollution during the rehabilitation and closure phase, apart from dust nuisance, is low. Only Total Suspended Solids, Smoke and Dust Fallout will be measured during this phase. Other pollutants will be measured when an obvious nuisance occurs, for the purposes of prosecution or mitigatory action, as directed by MICOA. Air Quality testing will be performed by an ISO 9000 accredited laboratory.

Applicable standards for the measurement of total suspended solids, smoke and dust fallout are:-

Total Suspended Solids:	24 hr average – 300 microgram/m^3
Smoke:	24 hr average – 250 microgram/m^3
Dust fallout (Deposition):	Slight – less than 0.25 g/m^2/day
	Moderate – 0.25-0.5 g/m^2/day
	Heavy – 0.5-1.2 g/m^2/day
	Very heavy – more than 1.2 g/m^2/day

The 24 hr limits are not to be exceeded more than 3 times per year.

3C-4.3 Noise Standards

The various applicable standards pertaining to the construction activities expected at the facility and access road include the following list:-

- SABS ARP 020:1992 – Sound Impact Investigations on Integrated Environmental Management
- SABS 0210:1996 – Calculating and Predicting Road Traffic
- SABS 0103:1994 – The Measurement and Rating of Environmental Noise with respect to Annoyance and to Speech Communication
- BS 5228 –1 – Noise Control on Construction and Open Sites – Part 1: Code of Practice for Basic Information and Procedures for Noise control.

SABS 0103:1994, in particular, is useful in identifying acceptable noise performance levels. Table 6 of this standard stipulates various increments of sound level increase, and the concomitant subjective impact experienced by the community experiencing it. This table will thus be used as a guideline for requirements espoused by the construction site.

Noise monitoring will be done on the assumption that the vast majority of plant and machinery fall within the acceptable noise levels. Where gross transgressions of noise regulations and guidelines exist, measurement and punitive action will be taken. It will be most appropriate to enlist the services of an ISO 9000 accredited acoustics laboratory rather than incur the cost of permanent monitoring equipment.

The SABS Codes Of Practice SABS 0103:1994 *The measurement and rating of environmental noise with respect to annoyance and to speech communication*, gives guidance as to acceptable noise levels. SABS 0103:1994 uses the unit of dBA, which is the

unit of a running average of noise over a fairly short period, with prescribed guideline limits for this parameter. The predominantly rural environment around the proposed site would be affected to a greater degree than other settings by the same level of noise. The appropriate noise limits are listed for different environments. SABS 0103:1994 uses the method of identifying typical ambient noise levels at each specific location and then to stipulate noise increases of increasing irritation to the receiver.

Typical ambient noise rating level (dBA):-

District	Daytime	Evenings/weekends	Night time
Rural (outside)	45	40	35
Quiet suburban (outside)	50	45	40
Urban (outside)	55	50	45
Industrial (outside)	70	65	60

Table 6 from the SABS 0103:1994, categorising expected group or community responses, is given below:-

	Estimated community/group response	
Excess ΔL_r / dB	Category	Description
0	None	No observed reaction
>0 ≤ 5	Little	Sporadic complaints
>5 ≤ 10	Medium	Widespread complaints
>10 ≤ 15	Strong	Threats of community group action
>15	Very strong	Vigorous community group action

Section 3C-5 Overarching environmental objectives during rehabilitation phase

The design and construction of the hazardous waste facility is aimed at minimumizing adverse impacts on the environment provided the approved operation plan is adhered to. Placing the waste in a contained system ensures no or nominal pollution of the physical environment such as water, air and the ground. Ensuring the system remains intact and under control based on operating procedures will limit the extent of any pollution of the environment of many years after closure of the facility.

Correct procedures followed by the operating contractor during the rehabilitation and closure process shall ensure minimum or no:

Pollution of the groundwater by containing the waste inside the landfill and limiting the ingress of rainwater into the waste body

Air pollution by covering and capping the waste body as well as revegitating the landfill to blend in with the surrounding area.

The monitoring of the rehabilitation and closure process shall be done by the Responsible Person, the Environmental Officer and Monitoring Committee. The records thus obtained shall be audited by the external landfill auditor and MICOA. The monitoring and auditing process shall ensure that a high standard on rehabilitation is maintained during the closure process Ongoing monitoring of the facility even after closure will ensure no unattended source of pollution that may develop .

Cognisance shall be taken of the local conditions and modus operandi, as they exist in Mozambique.

Section 3C-6 Determination of significant aspects during the rehabilitation and closure phase

Closure is the final step in the operation of a landfill. In order to close a landfill properly, however, closure shall be preceded by rehabilitation, to ensure that the site is environmentally acceptable. The site shall also be rendered suitable for its proposed end-use, set out in the Operation Plan. Where bad practice has occurred, this shall be rectified by means of remedial measures. Once the operation has ceased, aftercare will be necessary to ensure sustained acceptability.

The objectives of landfill closure are:

- To ensure public acceptability of the implementation of the proposed End-use Plan.
- To rehabilitate the landfill so as to ensure that the site is environmentally and publicly acceptable and suited to the implementation of the proposed end-use.

Where it is intended to close the landfill, the intention shall be made known by MICOA of intention at least one year prior to closure. This is because certain procedures shall be implemented and criteria met before closure.

Section 3C-7 Responsibilities of Environmental Officer (EO) and External Auditor (Monitoring Committee)

This section highlights the responsibilities of the EO and the external auditor in terms of the requirements of the EMP during this phase of the project.

3C-7.1 Environmental Officer

The Environmental Officer (EO) will be appointed by MICOA to oversee the implementation of the operation EMP on site, and will have no contractual or other agreement with the contractor to ensure unbiased judgement. The EO could be appointed full- or part-time, as required by MICOA. It is expected that a minimum of 2 site visits per month for the life time of the landfill facility is required for proper monitoring of implementation.

The EO has the authority to stop the works per formal site instruction notification, if in his opinion there is a serious threat to or impact on the environment due to the construction operations, until such threat or impact has been mitigated successfully. In such cases the EO must inform the Responsible Person (RP) and MICOA as soon as possible.

Upon failure by any employee of the contractor, including the contractor's agent, to show adequate consideration to the environmental considerations as described in this EMP, the EO may recommend that such employee be removed from site. All costs associated with the action will be borne by the contractor.

The EO will keep a site diary to record any significant incidents. This diary will be made available to the contractor, MICOA and the RP upon request. Records of the successful implementation or shortcomings of the implementation will be kept. The implementation status of the EMP will be a fixed agenda point for all site meetings and all outstanding EMP issues will be discussed and implementation actions with due dates recorded.

The EO will request environmental method statements from the contractor for specific sensitive or high-risk actions, at his discretion. It is important to note that the EMP is regarded as a 'live' document that can be changed should more effective methods of mitigation be proposed and accepted by the EO. MICOA will be updated on a monthly basis in this regard. All accepted method statements will be regarded as being part of the EMP documentation and are subject to all terms and conditions contained in the main EMP document. A method statement describes the scope of intended work step-by-step detailing what, how, where and when an action will take place, as well as detail on the proposed mitigation measures to meet the EMP requirements. No work may commence prior to the approval of the method statement by the EO.

The external auditor will prepare a short audit report after each audit for submission to MICOA.

3C-7.2 External Environmental Auditor

The external environmental auditor will be appointed by MICOA to audit the EO's records of implementation and success of mitigation measures adopted on site. It is expected that a minimum of one audit per 3 month-period for the duration of the operations period is required for proper auditing of the monitoring of implementation. The EMP will be criteria against which the EO will be audited.

Quarterly internal audits (i.e. audits conducted by MICOA personnel) shall be conducted, reports compiled for such audits, and these audits made available to external auditors. Should the Contractor perform audits, the reports of these audits will be forwarded to MICOA and the external auditors for their perusal.

Routine internal audits shall be carried out by the Contractor to check for compliance with the Operating Plan. These inspections should be monthly as specified in the Minimum Requirements. However if the operational aspects of the Site are found to be in compliance with the operational manual and all legislative requirements, the frequency of the audits shall

be reduced at the discretion of MICOA. Every six months an external audit by independent consultants should be undertake and the results submitted to MICOA.

The external audits will be carried out by a small team comprising representatives of MICOA, the Consultant and the Contractor, and may include representatives of local or national government departments.

It is noted that in addition to the above audits, the relevant authorities such as MICOA may carry out audits of the site. The Contractor is to allow such authorities access to the Site.

Section 3C-8 Mitigation and management proposals for significant aspects

3C-8.1 Landfill capping designs and construction procedures

3C-8.1.1 Introduction

The landfill shall be investigated before rehabilitation and closure can commence, so as to identify any closure requirements that must be implemented. Based on the results of the investigations, a closure or upgrade design shall be drawn up and presented in a Closure Report. Also in this report, the current status of the landfill is compared with the identified end-use and closure requirements, and recommendations will be made regarding required rehabilitation. The Closure Report shall be approved by MICOA and the IAPs before rehabilitation can commence. The site may then be closed and the End-use Plan be implemented.

3C-8.1.2 Progressive rehabilitation of completed areas

The progressive rehabilitation of landfills by means of capping and the subsequent establishment of vegetation will be required at the MAVOCO hazardous waste landfill. Capping shall be implemented on all areas where no further waste deposition will take place, and vegetation shall commence as soon as possible. Screening berms are the first areas where vegetation shall be established. This ensures that waste disposal operations take place behind vegetated berms. These are extended upwards in advance of the disposal operation to ensure continued screening. All final levels and slopes shall be in accordance with the landfill design and the End-use Plan. Slopes shall not be steeper than 1 in 2,5, as this will promote erosion.

3C-8.1.3 Final cover

Immediately on completion of an area, the final cover shall be applied. The thickness of the final cover shall be consistent and in accordance with the design. The final cover shall comprise material capable of supporting the vegetation called for in the End-use Plan. In order to prevent erosion and improve aesthetics, revegetation shall commence as soon as possible after applying the final cover. All covered surfaces on the landfill will be so graded as to promote run-off to prevent ponding. Re-vegetation shall commence as soon as is practically possible after the final cover has been placed, in order to rehabilitate on an ongoing basis.

3C-8.1.4 Participation in the operation

The standard of operation at the landfill shall be monitored and enforced by a Monitoring Committee. This shall comprise representatives of MICOA, the operator and representatives of those affected by the landfill. The objective of this committee is to provide a mechanism whereby the needs and concerns of the IAPs can be addressed in the operation of the facility. In the interests of transparency, IAPs should, through the Monitoring Committee, be given access to the site and information relating to the operation.

3C-8.1.5 Determination of End-use Requirements

The end-use of a landfill refers to its after-use, i.e. how it will be developed after closure, to fit into the environment. The site will therefore be closed in accordance with the approved End-use plan approved by MICOA. No public access will be permitted onto the closed hazardous waste landfill, because of the hazardous nature of the wastes contained therein. This will be clearly indicated by signposting.

With time, however, the situation associated with the landfill may well have changed. The end-use requirements shall therefore be reassessed and redefined.

The closure of a landfill will only be considered once MICOA is satisfied that the rehabilitation of the site has been properly carried out. This will include the implementation of the Closure Design and the carrying out of all the recommendations contained in the Closure Report. This will be assessed at a final site inspection attended by representatives of all the relevant state departments and the Monitoring Committee.

All of the preparations necessary to implement the End-use Plan and to maintain the landfill in an environmentally acceptable condition must have been completed before closure. Once MICOA is satisfied with the status of the rehabilitated landfill site, it will issue the Permit Holder with a letter approving the closure of the facility. This letter will allow the operator to physically close the landfill and will state that no further waste can be accepted. It will also set conditions for the implementation of the End-use Plan and for the ongoing inspection and maintenance of the landfill.

Consequently, before closure, the IAPs shall again be consulted regarding the end-use.

3C-8.1.6 Investigation of the Landfill to Determine Closure Requirements

The closure investigation shall be carried out to identify the causes of any existing problems and to provide the basis for the closure requirements. The extent of the investigation will depend on the amount of investigation already completed, the existing problems and the potential environmental impact of the site. Closure requirements will be those rehabilitation measures that shall be taken to render the landfill environmentally suited to its proposed end-use. Where problems have resulted from bad practice, remediation will be required. This may include remedial work with regard to drainage, leachate management and cover integrity. The closure requirements are included in the remedial or Closure Design.

3C-8.1.7 Closure Design

Aspects addressed in the Closure Design shall typically include the following:

- Remedial design to address identified problem areas
- Final shaping, landscaping and revegetation
- Final landfill cover or capping design
- Permanent storm water diversion measures, run-off control and anti-erosion measures
- Any infrastructure relating to the End-use Plan.

In considering each of the above aspects, reference shall be made to any earlier End-use Design. Any variations from the original concept shall be noted and their effect analysed.

3C-8.1.8 Closure Report

The state of the landfill at closure will probably not comply with the desired end-use and closure requirements, reflected in the Closure Design. The Closure Report therefore compares the current status of the landfill with the Closure Design and End-use requirements. Based on this comparison, recommendations shall be made regarding measures to upgrade the existing condition of the landfill to that desired. Recommendations of the Closure Report involve the implementation of the Closure Design and shall typically include details of rehabilitation measures. The Closure Report shall also include details of management, inspection, monitoring and maintenance plans.

3C-8.1.9 Written Acceptance

Written acceptance of both the Closure Design and the Closure Report shall be obtained from MICOA. In order to obtain this, an inspection of the landfill by the Responsible Person and a representative of the Department will be required. Once the Closure Design and the Closure Report have been accepted by MICOA and the IAPs, site rehabilitation may commence.

3C-8.1.10 Rehabilitation of Landfill

The rehabilitation of the landfill will ensure that the final condition of the site is environmentally acceptable and that there will be no adverse long term effects on the surrounding areas, the water regime or the population. It includes final cover, capping, topsoiling and vegetating. Any long term leachate, gas, storm water and erosion control systems required shall also be in place and in working condition before the landfill is closed. This will be detailed in both the Closure Design and the Closure Report.

3C-8.2 Re-vegetation and rehabilitation during closure

This section covers the proposed rehabilitation actions required where a section of the landfill has to be closed as well as re-vegetation procedures for rehabilitated and other disturbed areas.

3C-8.2.1 Rehabilitation actions after construction

Rehabilitation will be required at the construction camp and surrounds, the borrow pit or quarry, the crusher site, areas used for the stockpiling of material, other disturbed areas and temporary site roads and pedestrian paths.

All concrete slabs will be broken up and the rubble removed to an approved waste disposal site, or used in the rehabilitation of the borrow pits if approved by the EO. Surfaces below concrete slabs must be checked for any contaminants and if found contaminated soil must be removed. These surfaces, as well as all areas compacted under material stockpiles, are to be shallowly ripped and topsoiled. Topsoil will be replaced at depths of 100mm to 150mm. Topsoil should always be placed and spread when it is dry by means of hand raking or mechanical blading and trimmed to a uniform thickness not less than 100mm.

All temporary construction water and sewer pipes must be removed with the septic tank and excavations closed with compacted material.

Access roads and other temporary site roads and pedestrian paths where vegetation has been removed or destroyed, have to be ripped and topsoiled (if required).

Borrow pits will be filled with as much excess fill material as possible, but shall be kept free of any other waste with the exception of concrete rubble, if approved by the EO. If concrete rubble is disposed of in the borrow pits, it has to be placed at the bottom to ensure that it does not protrude after topsoiling. Borrow pits shall be covered up with soil from the original excavation of the borrow pit, or material from other approved sources.

No rehabilitated area will be left vulnerable to erosion and erosion will be monitored for erosion channels forming. Eroded areas will be repaired to limit the damage as soon as possible. All rehabilitated areas will be re-vegetated as per section 3C-8.2.2 below and will be protected from excessive trampling and vehicular access.

3C-8.2.2 Re-vegetation after rehabilitation

Re-vegetation of herbaceous cover and grass cover shall be of natural indigenous species occurring in the general environment of the site. Where natural indigenous species are not commercially available, acceptable non-invasive species approved by the EO shall be used.

An acceptable grass cover shall mean that not less than 80% of the seeded area be covered with grass and there shall be no bare patches of more than 500mm in diameter. The normal minimum application rate of seeds is 25kg of seed per hectare. Seed should be applied as per the supplier's guidelines. A fertilizer, 2:3:2 shall be added to the seed mix prior to seeding. On completion of the seeding the area shall be lightly raked parallel to the contours to cover the seed. A superphosphate shall be mixed into the soil during scarification. Areas that show now vegetation growth 9 months after completion of the rehabilitation work, will be ripped, additional topsoil spread and seeded with indigenous grass species.

If hydro seeding is preferred by the contractor, ridges approximately 100mm high and 400mm apart must be made parallel to the contours of the slope prior to hydro seeding.

Cellulose pulp must be added to the seed mix at a rate of 1500kg per hectare. If a soil stabiliser is used, the pulp can be omitted or used at a reduced rate. Alternative seed mixtures used does not change the contractor's responsibility to achieve adequate cover.

Tree and shrubs planting shall be done in naturally positioned mixed clumps to blend in with the natural species communities, as per the instruction of the EO. Trees and shrubs kept in the site nursery will be used for this purpose, supplemented by additional planting material sourced commercially, if in the opinion of the EO the nursery plants were not properly maintained during the operational phase.

All re-vegetated areas will be protected from excessive trampling and vehicular access.

Section 3C-9 Monitoring and auditing during rehabilitation phase

3C-9.1 Final closure audit

Once the landfill has been rehabilitated and approved to receive the closure material as per the closure design the closure the closure process shall proceed. Closure of the landfill as per the design shall be monitored by the EO and Responsible Person. Care shall be taken that the correct materials from allocated stockpiles are used and that no foreign vegetation are introduced as per the revegitation requirements.

Once all capping material and vegetation has been placed and planted a final inspection shall be carried out by the EO and Responsible Person. Through the process of rehabilitation and placing of cover material and vegetation continuous monitoring shall be done. All monitoring records shall finally be audited by MICOA and an external auditor.

3C-9.2 Future follow-up control monitoring

3C-9.2.1 Ongoing Inspections and Maintenance of the Landfill

The long term environmental impacts, public health, safety and nuisance problems associated with a landfill may persist long after the site has been closed. Ongoing inspections and maintenance will therefore be required after site closure to ensure that such problems do not continue unidentified and unabated, and that the End-use Design is properly implemented.

Ongoing inspections shall be carried out at regular intervals to monitor cover integrity, subsidence, fires, vegetation, drainage, erosion, and any other aspects of the closed site which could cause nuisances. Post-closure water quality monitoring shall also take place. The frequency of inspections or post closure audits will be determined in consultation with MICOA. Based on the findings of the ongoing inspections, maintenance would address the following aspects:

3C-9.2.1.1 Integrity of cover

Post-closure monitoring shall address the aspects of landfill cover integrity. Wherever there are breaches, these shall be identified, the cause investigated and the situation rectified by infilling.

3C-9.2.1.2 Drainage systems

It is essential to ensure that drains are not excessively eroded or filled with silt or vegetation. They shall be made to function in order to ensure that excess surface water does not enter the waste body.

3C-9.2.1.3 Subsidence

Any subsidence or cracks, due to settlement or any other cause, shall be identified and rectified by infilling.

3C-9.2.1.4 Fire

Any fires that result on the site shall also be identified, exposed and smothered with soil as soon as possible. Where the fires result on top of the landfill the cause for the fire shall be determined and the necessary emergency actions shall be taken.

3C-9.2.1.5 Vegetation

Vegetation planted for the purposes of rehabilitation, erosion control, beautification or the end-use shall be maintained to ensure that it achieves its purpose.

3C-9.2.1.6 Security

It is essential to ensure that illegal access and dumping does not occur on the closed waste disposal facility.

3C-9.2.2 Ongoing Monitoring and Public Participation

Any gas or water monitoring systems shall be maintained and monitored on an ongoing basis, after the landfill site has been closed. Gas and water monitoring shall comply with the Operating Plan and the EMP. Post closure monitoring may be carried out under the auspices of a Monitoring Committee. Where this is the case, the results of ongoing monitoring shall be submitted to the Monitoring Committee and made available for public scrutiny. The public may, through the Monitoring Committee, also monitor the landfill and report any problems that are observed to the Responsible Person.

Section 3C-10 Monitoring and Auditing During Rehabilitation and Closure Phase

3C-10.1 Introduction

The general objective of landfill closure monitoring is to verify that the landfill conforms to the required standards and the site Permit conditions. More specific objectives are:

- To ensure that the accepted site design is properly implemented.
- To quantify any effect that the rehabilitation and closure has on the environment, and, in particular, any effect on the water regime.
- To serve as an early warning system, so that any problems that arise can be *timeously* identified and rectified.

They might include the proper compaction and covering of waste, the integrity of drainage systems and the consideration of site impact.

Monitoring serves to quantify any effect of the rehabilitation process on the environment, especially the water regime, and act as an early warning system, so that any problems that arise can be identified and rectified. Such problems would include malfunctioning drainage systems and ground or surface water pollution. Any problems identified must be rectified as soon as possible. In addition, monitoring serves as a performance indicator, and hence as a control or management tool, for the landfill owner.

In this context, monitoring is a general term used as described above. Monitoring may be carried out by means of site inspections or audits, data collection, sampling, analysis and interpretation. It also involves monitoring the response of IAPs.

3C-10.2 Background

The disposal site shall be monitored by a Landfill Monitoring Committee which will include IAPs to identify problems and to keep the public informed of activities/developments on the closed landfill and surrounding areas. Monitoring information shall also be made available to the Committee

The auditing of the closed site will be done as required by MICOA or its representative to ensure that monitoring is being conducted responsibly on a continuous basis.

3C-10.3 The Required Extent and Frequency of Monitoring

It will be the duty of the Responsible Person to ensure that the minimum requirements for closure monitoring are applied to a degree commensurate with this hazardous waste landfill, the situation under consideration and the risk of polluting the environment, more specifically the water regime. Monitoring will be carried out to the satisfaction of MICOA, and the Responsible Person shall be required to provide additional information. This could include detail about how the site vegetation is re-establishing or whether there are any stability problems related to the landfill body.

3C-10.4 Landfill Site Monitoring

Auditing of the landfill may only be necessary a problem arises on site requiring some lengthy involvement to rectify the matter. Otherwise auditing may not be required after closure of the landfill apart from ongoing monitoring. Any monitoring information will be made available to the IAPs through Landfill Monitoring Committees, so that any problems identified can be discussed and addressed. A record of complaints received and actions taken must also be maintained.

3C-10.5 Monitoring Requirements

After closure monitoring shall comprise the collection, processing and interpretation of certain data. The required data, the format and the frequency with which it must be presented to MICOA would be specified in the Permit conditions. Most of the procedures outlined here would be included in the Operating Plan, which would also make provision for certain actions to be taken in response to any problems identified during monitoring.

3C-10.5.1 Collection and processing of other data

Certain climatic statistics shall be collected and analysed for control purposes. These may include rainfall from rain gauges, wind speed and direction, and A-pan evaporation rates. Such information would provide the insight required to manage the site water balance.

3C-10.5.2 Leachate and water quality monitoring

Regular sampling and analysis of leachate, ground and surface water, and the interpretation of the findings, shall be done by the Responsible Person. Records shall be maintained of any impact caused by the landfill on the quality of the water regime in the vicinity of the site. Additional samples shall be taken at other times, where this is considered necessary.

Water quality monitoring shall begin before the commissioning of a landfill site and will continue throughout and beyond its operation. Since post closure water quality monitoring may continue for up to 30 years after the closure of a landfill, it is seen to represent the final step in the landfill process.

The objectives of water quality monitoring are:

- To enable the Permit Holder to comply with the relevant Permit conditions and legislation.
- To indicate any escape of leachate into the water environment.
- To serve as an early warning system, so that any pollution problems that arise can be identified and rectified.
- To quantify any effect that the landfill has on the water regime.

A Water Quality Monitoring Plan will be required as part of the landfill operations. In this regard reference is made to the South Africa Department of Water Affairs and Forestry,

Waste Management Series, Second edition 1998, *Minimum Requirements for Monitoring at Waste Management Facilities.* This will involve background analyses, detection monitoring, investigative monitoring and post-closure monitoring.

The Water Quality Monitoring Plan ensures that the water quality in the vicinity of a landfill is regularly monitored and reported upon throughout its life, so that, where necessary, remedial action can be taken. Water quality monitoring is the responsibility of the Permit Holder, who must ensure that the level and the extent of monitoring is commensurate with the class of site under consideration, and hence in accordance with the MICOA's requirements.

3C-10.5.2.1 Surface water monitoring system

During the site investigation, surface water quality in any associated drainage feature shall be monitored both upstream and downstream of the proposed landfill. Sampling points shall be selected at representative, easily identified sites. The sampling points upstream of the proposed landfill will provide ambient background values. The sampling points downstream of the proposed landfill will ultimately indicate any pollution resulting from the site.

3C-10.5.2.2 Ground water monitoring system

The ground water monitoring system, which comprises boreholes, will be available as part of the site development obligations. For more detail in this regard, the reader is referred to the *Minimum Requirements for Monitoring at Waste Management Facilities.*

3C-10.5.2.3 Leachate monitoring system

As the MAVOCO site is a hazardous waste disposal sites, leachate management systems are required. The leachate collection systems therefore form part of the design and provision is made for future leachate monitoring.

Parameters

For consistency and for comparative purposes, the same water quality parameters shall be analysed for in both surface and ground water monitoring.

Parameters for Background and Investigative Monitoring
Ammonia (NH3 as N)
Electrical Conductivity (EC)
Alkalinity (Total Alkalinity)
Free and Saline Ammonia as N (NH4-N)
Lead (Pb)
Magnesium (Mg)
Boron (B)
Mercury (Hg)
Cadmium (Cd)
Nitrate (as N) (NO3-N)

Calcium (Ca)
pH
Chemical Oxygen Demand (COD)
Phenolic Compounds (Phen)
Chloride (Cl)
Potassium (K)
Chromium (Hexavalent) (Cr6+)
Sodium (Na)
Chromium (Total) (Cr)
Sulphate (SO4)
Cyanide (CN)
Total Dissolved Solids (TDS)

Other parameters will, however, be added by the Responsible Person, should they become necessary at this site.

Sampling

Ground water sampling methods and the treatment and storage of samples are those advocated in the *Minimum Requirements for Monitoring at Waste Management Facilities* and those advocated by Weaver in 'Groundwater Sampling'. [Ref. Weaver, J.M.C., *Groundwater Sampling*. Water Research Commission Project No. 339 TT 54/92.] Surface water sampling methods are somewhat simpler, however, in that grab samples may be taken from the surface water sampling points.

In the case of both surface and ground water sampling, clean bottles shall be used. These should be rinsed with the sample water, prior to taking the sample. Sample treatment prior to analysis would be the same in both cases and is indicated in the above references. The analysis of the samples must be performed using an acceptable method which is to the satisfaction of MICOA.

Reporting

The ground and surface water quality results from the pre-operation monitoring, together with the annotated designs of the monitoring systems, shall be submitted to MICOA for there approval as part of the Permit Application Report, i.e. the Water Quality Monitoring Plan.

3C-10.5.2.4 Post-closure Monitoring

Since a landfill can continue to pollute the ground and surface water regime long after the site has been closed, post-closure water quality monitoring shall be ongoing. The approach and systems for ground and surface water monitoring shall be used for this purpose. The emphasis in the case of post-closure monitoring, however, will be more on ground water monitoring, unless circumstances or MICOA dictate otherwise.

Post-closure water quality monitoring shall continue for 30 years after site closure, unless otherwise agreed with MICOA. Ongoing liaison with the Department must continue throughout this period, with regular reports as specified in the Permit.

3C-10.5.2.5 Public Participation

The results of the water quality monitoring results must be available for scrutiny by the Monitoring Committee.

3C-10.5.3 Monitoring of rehabilitated areas

Completed areas will require ongoing inspection and maintenance. This will include the repair of cracks and erosion gullies which allow water to access the waste and from which malodorous gases escape, and the filling in of settlement depressions and/or cavities. Ongoing maintenance of the established vegetation shall be required for a period specified by the MICOA.

3C-10.5.4 Health of workers

In terms of the Occupational Health and Safety Act, the Employer is responsible for the health and safety of the people under his or her jurisdiction. The Responsible Person shall therefore use his or her discretion in applying the Act and monitoring the health of workers. This will involve medical examinations.

3C-10.6 Environmental management committee

An environmental management committee is to be established for the operations phase of the project. This committee could comprise

- The Responsible Person
- Representative(s) of the contractor
- Representative(s) of MICOA
- The EO
- An Environmental Auditor
- Representative(s) of the local community

In addition to the responsibilities of the Responsible Person and EO detailed in this report, the various members of this committee will have the administrative responsibilities tabulated below.

Member	Responsibility
Resident Engineer (Chairman)	Liaison between Contractor and all other parties
Contractor's representative(s)	Assisting in evaluation of operations/monitoring methods Assisting the EO with testing and monitoring (as detailed in Weekly Report below) where required

Member	Responsibility
MICOA representative(s)	Confirming compliance with environmental policy and legislation on site Liaison with MICOA
EO	Compiling of monthly and non-conformance reports Conducting of pollution monitoring and monitoring as per this EMP Liaison with MICOA To take minutes of the environmental management committee meeting
Environmental Auditor	Reporting on auditing of EMP implementation. Provide guidance on EMP monitoring on site by the EO Act as external advisor if required
Representative(s) of the local community	Liaison with the local community

3C-10.7 Reporting and meeting requirements

Monthly meetings should be held involving all the members of the committee, with the exception of the external auditor who will attend only to report back after an audit, or if specifically requested to attend. The purposes of the meeting shall be

- To establish the suitability of the Contractor's methods and machinery in an effort to lower the risk involved for the environment
- To discuss possible non-conformance to EMP guidelines or environmental legislation
- To assess the general state of the environment on site and discuss any environmental problems which may have materialised
- To act as a forum for input into the operation phase by the MICOA representative and external environmental auditor
- To accommodate the local community in the decision-making process regarding social and environmental issues on site

Two kinds of reports should be compiled by the EO for study by the external environmental auditor and/or MICOA:

- A monthly report which will include:
  - i) Results of any atmospheric, water or noise pollution tests performed as per this EMP in the specific month. This testing will be conducted either by an outside contractor or by the EO with equipment acquired for the project.
  - ii) A description of exceptional conditions on site whether they be meteorological, personnel related, machinery related or otherwise.
  - iii) A description of any environmental accident or developments which could potentially develop into a non-conformance event by the contractor.
  - iv) Minutes from the Environmental Management Committee meeting.

- A non-conformance report which will describe, in detail, the cause, nature and effects of any environmental non-conformance by the Contractor and could stand as evidence

should legal action be required. A testing sheet for atmospheric, water and noise pollution must be included for each infringement indicating the details of the event including position on site, date and time. If possible a photo should also be included in the report. This report will also suggest mitigatory measures to correct the non-conformance (if necessary) and contemplate revisions to any of the strategies used in the construction phase, whether they pertain to monitoring or to construction methods used on site.

3C-10.8 Compliance monitoring and auditing responsibilities

This section covers the monitoring and auditing requirements during the rehabilitation and closure phase and includes sections on the environmental management committee, reporting and meeting requirements and testing frequencies.

3C-10.9 Potable water quality monitoring and treatment process, discharge water quality monitoring, air quality monitoring and noise monitoring

3C-10.9.1 Potable water quality monitoring and treatment

Water pumped from the boreholes for consumption on site shall be treated where necessary using nominal chemicals and disinfectants – sufficient to render the water quality to within the prescribed standards. The water in the storage containers or sumps shall be checked as per section 8.11 for the desired standards. Water brought to the site in a water cart shall also be checked for quality and the necessary treatment shall be applied when necessary.

3C-10.9.2 Discharge water quality monitoring

Uncontaminated water from discharging from site after say rain storms shall be sampled and tested for potential contamination. Should such contamination be observed the source shall be identified and the necessary steps taken to eradicated potential future contamination of the storm water run off.

Contaminated water shall not be discharged form site into the natural environment other than through attempts of evaporation. Contaminated water shall be contained in the holding ponds provided.

3C-10.9.3 Air quality monitoring

Hazardous air pollutants which could be dispersed from the landfill site as dust, or as gaseous substances will be monitored separately.

3C-10.9.3.1 Dust monitoring

Sampling of dust shall be done on site that entails sampling of dust that can be suspended, using a sampling approach that would ensure statistically that samples are representative of all possible sources of hazardous substances. Chemical analyses shall cover all substances that may be relevant to the materials and activities, using validated methods in a formal

quality assurance structure. Mathematical modelling of dust released from an area source, using the source profiles of hazardous substances, shall then be conducted to provide the necessary information to assess human exposure, and health risks. The mathematical dispersion modelling has to be done at the beginning of the monitoring programme, and the model can then be used with new input data after each analytical survey. The on-site dust at the landfill site shall be characterised at least once per year, or more frequently when activities on the site may change the dust compositions.

MICOA may request analyses of dust sources, followed by mathematical dispersion modelling and human health risk assessment, at more frequent intervals if hazardous substances are present at levels that may lead to unacceptable health risks to workers or communities.

3C-10.9.3.2 Monitoring for releases of volatile substances

Direct measurement using a surface emission isolation flux chamber shall be used as the preferable technique in Mozambique to characterise area source facilities with hazardous fugitive emissions. The location and number of test points shall be adequate to enable calculation of the emission rates of substances from the total area. Sampling and analysis shall cover the complete range of substances that are relevant to the source. The data will then be used in a mathematical dispersion model to predict exposure levels for the quantification of occupational and environmental health risks. Sampling and analyses techniques shall be done by suitably qualified personnel or institutions. The frequency of sampling and analysis will depend on the level of identified risk, but shall be at least once per year when activities and waste profiles do not change. After changes that could influence the emissions profiles, measurements shall be made to establish the new profiles and associated occupational and environmental health risks.

3C-10.9.3.3 Gas monitoring

The risk of gas explosion shall therefore be continually monitored. If monitoring indicates that there is any safety risk on account of landfill gas or other gaseous compound accumulation and/or migration, controls must be considered in consultation with the MICOA. Gas monitoring systems shall be installed at the landfill facility. These shall be monitored at three monthly intervals during the operation and at the discretion of MICOA after site closure. If the soil gas concentrations exceed 1% by volume at Standard Temperature and Pressure (STP), the Department must be informed. Trained personnel shall be consulted on any level of gas concentrations.

The operating plan shall contain information regarding Methane or other probable gas concentration in the atmosphere inside buildings on or near the site as well as the procedures to follow in the various cases.

Apart from explosion potential, however, landfill gas also contains a wide range of volatile organic compounds that are classified as hazardous air pollutants. Where significant landfill gas is present, therefore, samples shall be taken at various positions at the landfill site, and characterised for volatile organic compounds.

Sampling can be direct at gas wells, or using approved specialised techniques. The volatile organic compound compositions of the landfill gas shall then be subjected to occupational and environmental health risk assessments. This will be done at the discretion of MICOA to ensure against unacceptable health risks to workers or communities. Gas monitoring shall continue after landfill closure, until MICOA is satisfied that landfill gas no longer represents a risk.

3C-10.9.4 Noise monitoring

The Responsible Person shall continuously be observant to the generation of any unduly noise. The potential for noise emanating from any machinery or motors, such as pumps, machinery and vehicles offloading containers, shall be checked for any irregular noise. Should there be any doubt as to whether the noise experienced is outside the acceptable norm this shall be checked against the stated noise standards and reported as part of the site daily record.

Sharp noises generated by hooters or sirens will be avoided as these will travel long distances and may damage the essentially rural atmosphere of the area

Standards tests shall be performed once every two months and shall form part of the EO report.

3C-10.10 Testing frequencies

Compliance monitoring and testing will be done as per this EMP to monitor EMP implementation and compliance and initiate corrective action if required. The EO will develop sample sheets for regular monitoring and testing, as well as establish a proper filing system for record keeping purposes.

Testing frequencies for different aspects are listed below. Table 1 lists the required frequencies for monitoring requirements:

- Potable water quality monitoring – every 2 weeks and more often if specific complaints are received from personnel or labourers
- Discharge water quality monitoring - every 2 weeks and more often if specific complaints are received from personnel or labourers
- Air quality monitoring – every month for the duration of earthworks, blasting and other dust-generating activities and when specific complaints are received from the communities surrounding the site
- Noise monitoring - every month for the duration of earthworks, blasting and other noise-generating activities and when specific complaints are received from the communities surrounding the site

Table 1 - Minimum monitoring requirements for the Mavoco Hazardous Waste Landfill

Monitoring requirements	Frequency
Rainfall	D
Evaporation	D

Monitoring requirements	Frequency
Run-off (volume, quality)	D
Water infiltration on waste	M
Toe seepage from waste	M
Soil cover on waste	M
Vegetation on waste or soil	M
Bioassaying	Y
Pressure vacuum lysimeters	M
Gas samplers	M
Electrical conductivity probes	
Leachate collectors	M
Temperature within waste	
Special detectors	M
Special monitoring holes	Yes
Other holes	Yes
Groundwater levels	M
Groundwater chemistry	M
Borehole yield	Y
Groundwater usage	Y
Fountain seepage	M
Water balance	Y

D = Daily, W = Weekly, M = Monthly, Y = Yearly

References

South Africa, Department of Water Affairs & Forestry, Second Edition, 1998. Waste Management Series. Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste.

South Africa, Department of Water Affairs & Forestry, Second Edition, 1998. Waste Management Series. Minimum Requirements for Waste Disposal by Landfill.

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