EQUINOX
COPPER VENTURES LIMITED

LUMWANA COPPER PROJECT

ENVIRONMENTAL IMPACT ASSESSMENT

JULY 2005

EXECUTIVE SUMMARY

This Environmental Impact Assessment (EIA) has been prepared in support of the environmental assessment of the Lumwana Copper Project by the Government of the Republic of Zambia.

Equinox Copper Ventures Limited (ECV), a Zambian registered company and ultimate subsidiary of Equinox Minerals Limited, a Canadian/Australian explorer and resource development company, plans to develop the Lumwana Copper Project which is located in the North Western Province of Zambia approximately 300 km by road from the Copperbelt city of Kitwe and 95 km west by road on provincial centre of Solwezi.

The Project has a planned life of mine of 18 years and will involve the mining of two distinct areas. Area 1 is the Malundwe deposit which will be mined from year 1 to 5. Area 2 is the Chimiwungo deposit and will be mined from year 6 to 18.

On average 20 million tonnes of copper ore will be mined each year, producing an average of 500,000 tonnes of copper concentrate each year. The copper concentrate will be transported by road to the Zambian Copperbelt or elsewhere in Southern Africa for further processing to copper cathode.

The operation will use conventional open pit mining and processing techniques with the main components of the project being:

- Malundwe main and east pits;
- Chimiwungo main, south and east pits;
- Malundwe and Chimiwungo waste rock dumps;
- Processing, maintenance and administration facilities to support the operations;
- Tailings storage facility;
- A number of fresh water dams;
- 330 kV power line from Solwezi to the Project;
- Residential estate with up to 3000 dwellings; and
- Associated infrastructure to support the above

All ECV employees will be provided with accommodation in the newly constructed Lumwana Estate which will provide all the facilities of a large, modern town such as hospital, schools, recreational facilities and the resultant business development opportunities that would be expected for such a development. For Zambian citizens, who are permanent employees of ECV this will also provide an opportunity to purchase a house with an affordable loan repayment system.

The North-Western Province of Zambia has had little development over the last 20 years and there are no active mining operations in the area. It is anticipated that the Lumwana Project will make a significant positive socio-economic contribution to the area including the extension of reticulated power to the area and the upgrading of the main T5 highway (committed to by the GRZ).

The project is located within Large Scale Mining Licence 49 (LML-49). It is expected to disturb an area of approximately 8,700 hectares, of which nearly 5,000 hectares is within the Acres No. 105 National Forest. There are no private landholdings or residential dwellings within the proposed disturbance areas of LML-49 or the associated infrastructure areas. Project development will not require the relocation of any indigenous people.

An environmental baseline study was completed as a component of the Bankable Feasibility Study (BFS) in 2003. The Lumwana East River and its major tributaries, the Malundwe stream and Chimiwungo stream, are the main water courses in the project area. Surface water quality across the project are similar and generally of good quality. However aluminium, selenium, lead, uranium and cadmium concentrations occasionally exceed Zambian Drinking Water Quality Standards. Bacterial faecal coliform counts recorded at all monitoring sites during the wet season when the baseline monitoring was conducted also exceeded the Zambian Drinking water Quality Standards. Relatively high concentrations of aluminium, boron, iron and uranium were recorded in most of the stream sediments.

Groundwater sampled in village wells along the T5 highway is generally of good quality. By contrast the electrical conductivity, total dissolved solids and sulphate concentrations are elevated in groundwater at the Malundwe deposit.

Soils close to the mineralised deposits exhibit relatively high copper values. Away from the copper deposits, element concentrations are low or below detection limits except for aluminium and iron.

The soils of the area are typical of those found in sub-tropical regions, being heavily leached, low in nutrients and of poor fertility. Subsistence farming is practiced using the traditional *Masala* method (slash-and-burn). Farming is the main source of livelihood. The main crop harvested is cassava with maize, sweet potatoes, beans and pineapples grown in the slightly more fertile dambo (wetland) soils. Cultivated land is concentrated close to the main road.

Wildlife was once abundant in the project area, however during the last 30 years or so, the larger mammals have been killed or forced to move out of the area as a result of over hunting, poaching and population pressure. Small mammals such as Duiker, Bush Baby and Velvet Monkey are occasionally reported, whilst small reptiles and birds are commonly sighted.

The baseline survey discovered pre-historic rock engravings close to the Lumwana East River in an area that will be affected by the construction of the dam wall and waste rock dump. The rock engravings onsite of pockmarks and includes strokes on rock faces. The engravings will be removed and preserved prior to project construction if necessary.

A background radiation survey was conducted in the two planned mining areas because there is uranium associated with the deposits. Whilst uranium will not be processed, it will be selectively mined and stockpiled within discrete zones of the waste rock dumps to allow for the potential of downstream processing if it proves economic.

The major potential social and environmental impacts of the project are:

- The development of the project will require the significant disturbance of up to 8,700 hectares of land. Whilst the footprint is large, the area where flora and fauna will be severely impacted is small in relation to the total area of woodlands in the North Western Province. The impact is local and not likely to affect the ecology of the region. The impacts on flora and fauna will be reduced by progressive revegetation and rehabilitation of affected areas. Local provenance species will be used wherever possible and closure criteria developed to ensure that a sustainable landform is developed.
- Impacts on surface water quality could arise from contamination by spillage, accidental release from plant area, the tailings storage facility or from mine dewatering water and drainage water entering the Lumwana East River. Controlling direct runoff from operational areas into local watercourses will reduce the impact of the mine on surface water. ECV will ensure that no water leaving the site exceeds statutory standards and that mitigation measures such as hydrocarbon traps and sedimentation ponds will be utilised in areas where potentially contaminated water may discharge.
- Seepage through the base of the waste rock dumps or the tailings storage facility could impact the groundwater quality. Geochemical characterisation studies undertaken on the Malundwe tailings and sulphidic waste rock indicate both materials to be non-acid –forming. On this basis, the risk of acid rock drainage occurring is considered to be low. This will be monitored on an ongoing basis.

- Discharge from the tailings storage facility could potentially impact the Lumwana East River. However metallurgical test work performed on the Malundwe tailings slurry indicates that the effluent will comply with Zambian Standards and where appropriate World Bank Guidelines and United States Environmental Protection Agency (USEPA) limits for effluent discharge. The tailings storage facility is not designed to overflow, although low quantities of seepage may discharge from the toe of the facility. This will be monitored to ensure Zambian limits are met at all times.
- Radiation levels in plant effluent will comply with USEPA limits. There will be very low levels of uranium in the tailings solids (33 ppm) and liquid phases (0.16 mg/L).
- Construction of the Lumwana East River diversion to make way for the Malundwe main and east pits and waste rock dump and tailings storage facility will have a permanent environmental impact. However, the loss of aquatic flora and fauna and riverine forest will be limited and the aquatic ecosystem of the upstream and downstream sections of the Lumwana East River will not be adversely impacted. ECV will ensure adequate flow rates are maintained through the construction and operational phases of the project.
- The project investment will introduce beneficial multiplier effects in the local and regional economy. The project will promote the business of local suppliers and contractors providing goods and services to the mine. A direct favourable economic impact of the project in Lumwana will be the additional employment earnings generated in the local economy.
- From a socio–cultural perspective, the project is likely to attract people from the surrounding areas and beyond seeking employment. This will put the local population in direct competition with outsiders, a concern already expressed at the project EIA consultation meeting held at Lumwana. Depending on experience and availability of jobs, ECV is committed to employing local residents from Lumwana and Solwezi in preference to others. ECVs proposed construction of the Lumwana Estate with infrastructure such as hospital, schools and the development of key infrastructure such as power and water treatment facilities is an important positive impact for the welfare of the local community at Lumwana.
- Transport of concentrate and general mine related traffic will increase road traffic, particularly between Lumwana and Solwezi. Upgrading of the T5 highway and incorporating a pedestrian area adjacent to the road will mitigate against some of the issues, education and display of information will be used locally to ensure the issues are managed.
- The key health issues of the North Western Province are malaria and HIV/AIDS prevalence. A proactive approach with education and awareness will be utilised with ECV employees to reduce the impact of these diseases and improve conditions overall.

A Health, Safety and Environmental Management System will be implemented to manage the health, safety and environmental aspects in a manner that is planned, controlled, monitored, recorded and audited.

An Environmental Management Plan and Social Management Plan to manage these and other less significant impacts have been developed and included as part of the EIA. The approach is based on ECV's Sustainability Policy, Zambian legislation, World Bank Guidelines and industry best practice.

Prior to construction, and Environmental Monitoring Program will be implemented that will focus on surface water, ground water, air emissions and the land. The plan will monitor environmental performance and compliance with statutory regulations and other relevant guidelines and limits.

ECV will implement internationally accepted occupational health and safety standards and procedures throughout its operations t create a safe workplace thereby protecting its employees from accidents and sickness. ECV will also implement education programs to stop the spread of HIV/AIDS and malaria.

The Mine Reclamation Plan will focus on the reclamation of open pits, waste rock dumps, the tailings storage facility and all other infrastructure with the prime objective of returning the land to conditions capable of supporting the former land use or alternative sustainable land uses. The intent is to ensure no significant effects on adjacent water resources. Progressive rehabilitation will be undertaken at all times when areas become available, therefore leaving minimal works outstanding at mine closure except for plant decommissioning.

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LIST OF TERMS AND ABREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
AMC	African Mining Consultants
AMSL	Above Mean Sea Level
ANC	Acid Neutralisation Potential
ARD	Acid Rock Drainage
BFS	Bankable Feasibility Study
BSI	British Standards Institute
CEC	Copperbelt Energy Corporation
CHIM	Chimiwungo
DA	Development Agreement
DAPP	Development Aid from People to People
DRC	Democratic Republic of Congo
EC	Electrical Conductivity
ECV	Equinox Copper Ventures Limited
ECZ	Environmental Council of Zambia
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EQN	Equinox Minerals Limited
ERP	Emergency Response Plan
FAO	Food and Agriculture Organisation
GIS	Geographical Information System
Golder	Golder Associates Pty Ltd
GPS	Global Positioning System
W	Groundwater
HDI	Human Development Index
HDPE	High Density Polyethylene
HSE	Health, Safety and Environment
IAEA	International Atomic Energy Agency
ICRP	International Commission for Radiological Protection
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
IUCN	International Union for the Conservation of Nature
K	Permeability
km	Kilometre
Kvaerner	Kvaerner (E & C) Australia Pty Ltd
LEAD	Leadership for Environment and Development
LER	Lumwana East River
LME	London Metal Exchange
LML	Large Scale Mining Licence
LUM	Lumwana
MAFF	Ministry of Agriculture, Forestry and Fisheries
MAL	Malundwe
MAR	Mean Annual Runoff
MMSD	Mining Minerals and Sustainable Development
MPA	Maximum Potential Acidity
MSD	Mines Safety Department
MSDS	Material Safety Data Sheets
NAF	Non-Acid-Forming
NAG	Net Acid Generation
NAPP	Net Acid Producing Potential
NGO	Non-Governmental-Organisation
NHCC	National Heritage Conservation Commission
OB	Waste rock Dump
OHS	Occupational Health and Safety
PLS	Pregnant Liquor Solution
PMF	Probable Maximum Flood
PRA	Participatory Rural Appraisal
QA/QC	Quality Assurance/Quality Control
RBZ	Radiation Board of Zambia

RC	Reverse Circulation
REM	Radiation Equivalent Man
RHC	Rural Health Clinic
RL	Retention Licence
RLE	Roast-Leach-Electrowin
RoM	Run-of-Mine
RST	Roan Selection Trust
SED	Sediment
SOR	Sulphide Oxidation Rate
SMP	Social Management Plan
SRK	Steffen, Robertson and Kirsten
SW	Surface Water
TDS	Total Dissolved Solids
TOR	Terms of Reference
TSF	Tailings Storage Facility
TSS	Total Suspended Solids
UNHCR	United Nations High Commissioner for Refugees
USDA	United States Development Agency
USEPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
Vol	Volume
WB	World Bank
ZAMSIF	Zambia Social Investment Fund
ZESCO	Zambia Electricity Supply Company

Bq/l	Becquerels per litre
Bq/m^2	Becquerels per square metre
cu.m	cubic metres
dB	decibel
Ha	Hectare
Ktpa	Kilo tonnes per annum
l/s	litres per second
mg/l	milligrams per litres
mg/m^3	milligrams per cubic metre
mR/hr	milli Roentgen per hour
Mtpa	Million tonnes per annum
m/s	metres per second
mg/kg	milligrams per kilogram
mSv/yr	milli Sieverts per year
ppm	parts per million
tpd	tonnes per day
μS/cm	micro Siemens per centimetre
μg/m^3	micro grams per cubic metre

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1. INTRODUCTION

1.1 Background

The Lumwana Copper Project is located in the North Western Province of Zambia approximately 300 km by road from the Copperbelt city of Kitwe and 95 km west by road on the North West Highway (the T-5) of the provincial centre of Solwezi at latitude 12°26' South and longitude 25°85' East (Figure 1-1).

In October 2003 a Bankable Feasibility Study (BFS) was completed by Equinox Copper Ventures Limited (ECV) which indicated the Lumwana Project, with an expected mine life of 18 years, was technically and economically viable. A Large Scale Mining Licence (LML-49) was subsequently applied for and granted in January 2004 for a period of 25 years. This area is shown on Figure 1-1 and covers an area of 1,355 km^2.

A Large Scale Mining Licence, LML-49 was granted to Equinox Copper Ventures (ECV) in January 2004 (at that time with joint venture partner Phelps Dodge (Zambia) Limited) for a period of 25 years. This area is shown on Figure 1-1. LML-49 covers an area of 1,355 km^2.

It is standard procedure under the EIA Regulations for the Developer (in this case ECV) to first produce an Environmental Project Brief (detailed Scoping Study Report), which is submitted to the Mines Safety Department (MSD) and the Environment Council of Zambia (ECZ) for review. After reviewing the project brief the ECZ assess whether or not the project environmental impacts are likely to be significant. If significant, the Developer is requested to undertake a full EIA.

Due to the nature of the project and planned large-scale mining operations, the ECZ instructed ECV not to produce a project brief and to proceed directly to the EIA (Environmental Impact Assessment) stage.

Following completion of the BFS, granting of LML-49 and a decision to proceed with the project, environmental approval from the ECZ is now requested for the project on the basis of this EIA.

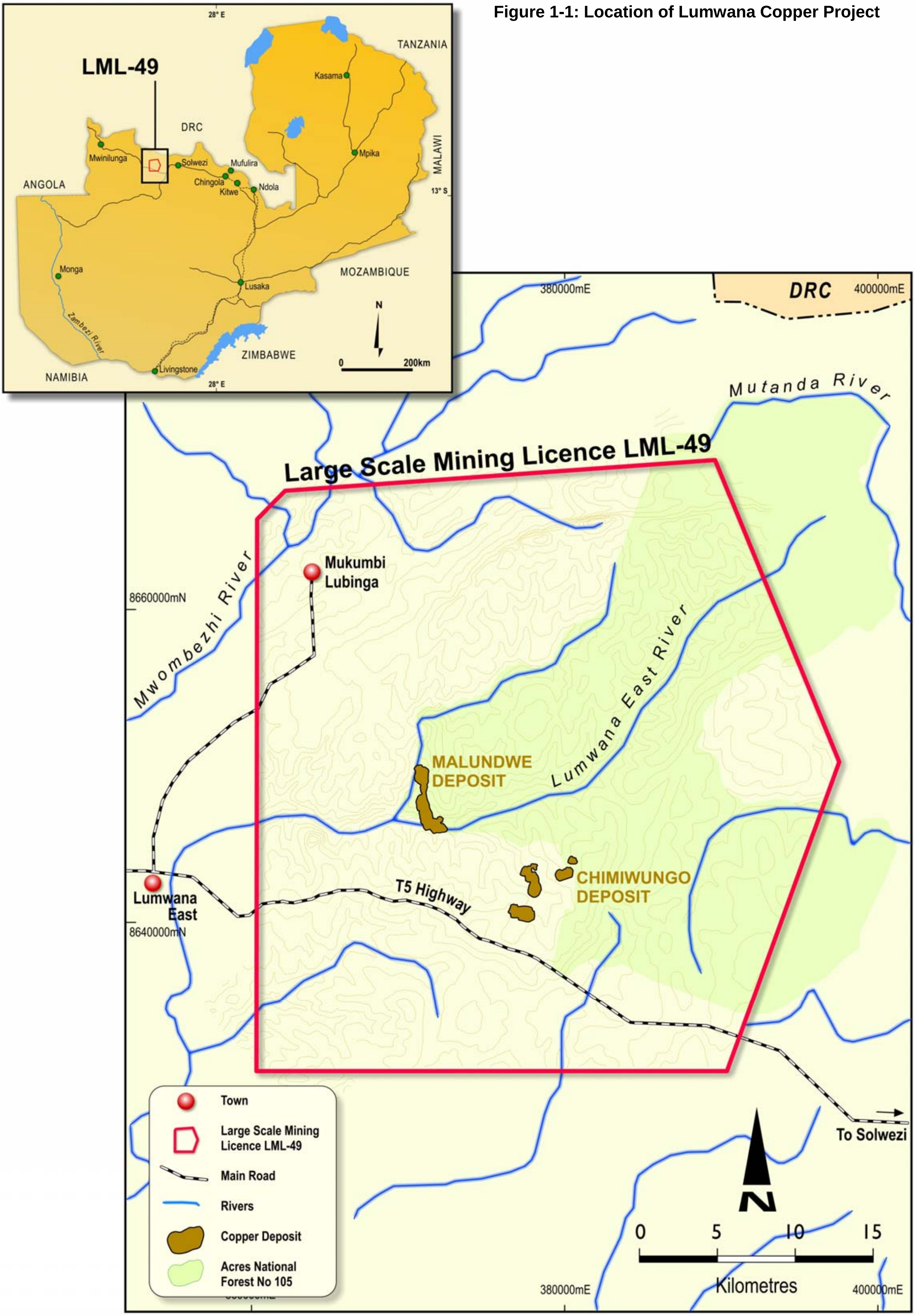
It is standard procedure under the Zambian EIA Regulations for the Developer to first produce an Environmental Project Brief (detailed Scoping Study Report), which is submitted to the Mines Safety Department (MSD) and the Environment Council of Zambia (ECZ) for review. After reviewing the project brief the ECZ assess whether or not the project environmental impacts are likely to be significant. If significant, the Developer is requested to undertake a full EIA. Due to the nature of the project and planned large-scale mining operations, the ECZ instructed ECV not to produce a project brief and to proceed directly to the EIA (Environmental Impact Assessment) stage.

1.2 History of the Project

The first prospecting in the Lumwana region was conducted by Rhodesian Congo Border Concession Limited between 1923 and 1940 which resulted in the discovery of the Malundwe copper clearing and malachite bearing schists in the streambed of the Lumwana East River. The first systematic exploration in the region commenced in 1947 by Roan Selection Trust (RST). Various companies including Roan Consolidated Mines (RCM), Mindeco Ltd, a precursor to Zambian Consolidated Copper Mines (ZCCM), Italian petroleum company, AGIP and French nuclear resources company COGEMA have held tenure over the area and undertaken mineral exploration for copper and uranium until 1990.

In October 1992 Phelps Dodge Mining (Zambia) Limited (Phelps Dodge) was granted a Prospecting Licence (PL-948). This licence was renewed in April 1995 for a further two years as PLLS-1118 under the new Zambia Mines and Minerals Act, 1995. In November 1996 Phelps Dodge applied for a Retention Licence to cover the eastern area of PLLS1118 and relinquished the remainder. The 1,355 km^2 Retention Licence RL-01 was granted to Phelps

Figure 1-1: Location of Lumwana Copper Project



Dodge in October 1997 for an initial period of 3 years. This was the first retention licence to be granted under the new Zambia Mines and Minerals Act, 1995. Phelps Dodge applied for a renewal of RL-01 in September 2000, which was subsequently granted for a further 3 years in January 2001. The retention licence confers on the holder exclusive rights to apply to the Minister of Mines under the Mines and Minerals Act, 1995 for a large-scale-mining licence within the area for which RL-01 was granted.

In August 1999 Equinox Copper Ventures Limited (now Equinox Minerals Limited) entered into a Joint Venture with Phelps Dodge and in December 1999 became manager of the Lumwana Joint Venture. In 2000 Equinox, as Equinox Copper Ventures (ECV), completed a Pre-feasibility Study and in November 2001 ECV commenced a Bankable Feasibility Study (BFS) using Aker Kvaerner as Principal Consultants and Golder as subcontractor responsible for all geoscientific, environmental and tailings dams studies. This BFS, completed in October 2003, included an extensive two phase resource definition, metallurgical sampling, geotechnical and hydrogeological drilling program (November 2001 to February 2002 and April to November 2002) and a comprehensive baseline environmental study, the results of which are incorporated as part of this EIA.

During 2004 ECV conducted further exploration to provide additional confirmatory data for the project design. In addition, the program discovered the Chimiwungo North deposit immediately north of the Chimiwungo Main pit.

1.3 Location and Land Tenure

The project is located approximately 65 km due west of the provincial city of Solwezi (85 km by road) in the North Western Province of Zambia (Figure 1-1). The project is approximately 45 km south of the border of the Democratic Republic of Congo and 200 km east of the Angolan border.

It is situated within Large Scale Mining Licence 49 (LML-49) granted in January 2004, for a period of 25 years and renewable for a further 25 years (Figure 1-1).

The majority of the mine site falls within the Acres No.105 National Forest; located within customary land which although vested in the Crown is held in trust by the local Chief, His Royal Highness, Chief Mukumbi Ibaloli.

There are no private land holdings or residential dwellings within the proposed disturbance area of LML-49, or proposed infrastructure disturbance areas.

1.4 Timing

It is anticipated construction of the project will commence immediately upon receipt of the necessary approvals and funding. This is currently planned for the fourth quarter of 2005, with mining activities commencing in late 2006 and plant commissioning and concentrate production mid-2007.

1.5 The Developer

The Lumwana Copper Project is wholly owned by Equinox Copper Ventures Limited (ECV) a Zambian registered company.

ECV is an ultimate subsidiary of Equinox Minerals Limited (Equinox), an integrated Australian explorer and resources development company dual listed on the Australian Stock Exchange since 1994 and the Toronto Stock Exchange since 2004 (trading as EQN). The major shareholding in Equinox is primarily held by Canadian, European and Australian institutions (70%) with directors and management holding 13%. The remaining shares are held by individual private investors. Approximately 2,000 individual shareholders are on the EQN share register.

1.6 Regulatory Framework

1.6.1 Zambian Environmental Regulations Applicable to Mining Projects

The Zambian Environmental Regulations applicable to the Lumwana Copper Project include, but are not limited to the following:

- The Environmental Protection and Pollution Control Act;
- The National Heritage Conservation Commission Act;
- The Mines and Minerals Act;
- The Ionising Radiation Act;
- The Mines and Minerals (Environmental) Regulations;
- The Environmental Protection and Pollution Control (Environmental Impact Assessment) Regulations;
- Water Pollution Control (Effluent & Waste Water) Regulations;
- Air Pollution Control (Licensing and Emission Standards) Regulations;
- Waste Management (Licensing of Transporters of Wastes and Waste Disposal Sites) Regulations;
- Pesticides and Toxic Substance Regulations;
- Mines and Minerals (Environmental Protection Fund) Regulations;
- Hazardous Waste Management Regulations;
- Environmental Regulations; and
- Ionising Radiation Protection Regulations.

ECV is committed to comply with all of the above legislation (and other statutes which may apply), which regulates most aspects of interaction between the project and the natural environment.

1.6.2 Justification for the Environmental Impact Assessment

The Lumwana Copper Project Environmental Impact Assessment (EIA) has been undertaken in accordance with the requirements of the Environmental Protection and Pollution Control (Environmental Impact Assessment) Regulations, 1997. The ECZ established under the Environmental and Pollution Control Act, 1990 is responsible for EIA review and approval and for monitoring the implementation of the Developer's Environmental Management Plan.

ECV management has maintained close contact with the ECZ and the Mines Development Department throughout the preparation of this EIA document, keeping both bodies informed of project design changes and other developments.

A BFS was completed in 2003; an environmental study was a component of the BFS and was completed at that time. ECV appointed Golder Associates Pty Ltd (Golder) and African Mining Consultants (AMC) as project environmental consultants in October 2001. This EIA has been prepared incorporating the data from the BFS and a greater database of knowledge on the resource, social aspects and environmental factors completed since 2003.

1.6.3 Review of the Environmental Impact Assessment

Review of the EIA will be undertaken in accordance with ECZ requirements which require the following:

- 12 copies of the EIA submitted to the ECZ;

- EIA publicly advertised and put on display for 14 days, whilst a public hearing is not mandated, it is likely that the ECZ will hold one and ECV will be in attendance to comment or answer questions;
- EIA distributed to relevant authorising agents who will make comments on the report within 30 days of receipt;
- ECZ decision (approval with or without conditions, or reject the project) within 60 days.

In arriving at its decision the Council will take into account:

- Impact predictions made in the EIA;
- Comments from interested and affected parties;
- The report of a person presiding over a public hearing (where applicable); and
- Any other factor the Council considers crucial in the particular circumstances of the project.

The Environmental Regulations specify that a review fee must be submitted together with the EIA document. The review fee is calculated on the basis of the project's capital cost. Based on the project capital cost of the Project being greater than US$50,000,000 the EIA Review fee is US$150,000.

Environmental regulations require the EIA to be updated annually to reflect any changes to the mining operation and/or the environmental management plan. The regulations further specify that an environmental audit of operations be undertaken between 12 and 36 months after project commencement. This audit will focus on environmental performance and implementation of the environmental and social management plans. The ECZ will advise on the frequency of subsequent audits.

1.6.4 Project Development Agreement

Under the Mines and Minerals Act, the Minister of Mines may require the Developer to enter into a Development Agreement (DA) with the Government of the Republic of Zambia (GRZ). The purpose of this agreement is to encourage and protect large-scale investments in Zambia. In the agreement, ECV reaffirms its EIA commitment to comply with all of the Environmental Regulations of Zambia and implement its Environmental Management Plan. It is anticipated the DA will be finalised and signed by both parties by August 2005, prior to commencement of construction.

1.7 International EIA Guidelines

In developing this EIA and implementing all management plans, reference will be made to the World Bank Guidelines and Equator Principles discussed in the following sections. Equinox will comply with all relevant requirements.

1.7.1 World Bank Guidelines

Most international financial institutions and banks have introduced regulations and guidelines, which compel project proponents to undertake a Project EIA. These regulations/guidelines are usually based on the World Bank Guidelines for Environmental Assessment (Operational Policy 4.01 - January 1999). The World Bank's environmental policy reflects international environmental standards, which are collectively known as the World Bank Group (WBG) standards.

Although alternative protocols and standards do exist, the WBG standards are considered to be the international benchmark for environmental assessment. An EIA performed to WBG standards will satisfy most financial institutions.

The content of a Zambian EIA is analogous to that of a World Bank Environmental Assessment Report for a Category A Project i.e. a project *likely to have significant adverse environmental impacts that are sensitive, diverse or unprecedented*.

The content of a Zambian EIA and World Bank environmental assessment are summarised in Table 1-2.

Table 1-1: Content of Zambian EIA and World Bank Environmental Assessment

Zambian EIA	World Bank Environmental Assessment
Executive Summary	Executive Summary
Detailed Project Description	Policy, Legal and Administrative Framework
Baseline Environmental Study	Project Description
Environmental Impacts	Baseline Data Collection
Mitigation Measures	Environmental Impacts & Mitigation Measures
Analysis of Alternatives	Analysis of Alternatives
Environmental Management Plan (EMP)	Environmental Management Plan (EMP)
Appendices	Appendices

1.7.2 Equator Principles

The Equator Principles were developed in 2003 to provide a set of guiding principles for determining, assessing and managing environmental and social risk in project financing. A range of financial institutions have adopted these principles and as such ECV is expected to comply with the requirements as a condition of financing.

In committing to this the EIA must address the following:

- An assessment of the baseline environmental and social conditions;
- Requirements under host country laws and regulations, applicable international treaties and agreements;
- Sustainable development and use of renewable natural resources;
- Protection of human health, cultural properties and biodiversity, including endangered species and sensitive ecosystems;
- Use of dangerous substances;
- Major hazards
- Occupational health and safety;
- Fire prevention and life safety;
- Socioeconomic impacts;
- Land acquisition and land use;
- Involuntary resettlement;
- Impacts on indigenous peoples and communities;
- Cumulative impacts of existing projects, the proposed project and anticipated future projects;
- Participation of affected parties in the design, review and implementation of the project;
- Consideration of feasible environmentally and socially preferable alternatives;
- Efficient production, delivery and use of energy;
- Pollution prevention and waste minimisation, pollution controls (liquid effluents and air emissions) and solid and chemical waste management.

Reference must be made to the minimum standards applicable under the World Bank and IFC Pollution Prevention and Abatement Guidelines and applicable IFC Safeguard Policies.

1.8 Objectives and Structure of the EIA

The objective of the EIA is to provide relevant details of the Project, the potential impacts and proposed management measures to minimise and control any potential adverse impacts. The information provided in the EIA should enable the environmental acceptability of the project to be assessed.

The main text of the EIA is structured in five major components:

- Introduction and benefits of the project (Sections 1 and 2);
- Description of the existing biophysical and social environment (Section 3);
- Project description (Section 4);
- Environmental and social issues and their management (Sections 5 and 6).

The EIA also contains appendices to support the information provided in the main text of the document.

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2. BENEFITS OF THE PROJECT

Developing the Lumwana Copper Project will:

- Enable the development of key regional infrastructure (such as water and power) to the North Western Province of Zambia, which by its nature is remote and isolated;
- Provide training and employment opportunities for up to 1,500 Zambian nationals;
- Positively influence the economy of Zambia through direct and indirect employment and local suppliers of goods and services;
- Develop a housing estate with all key modern facilities in an area previously devoid of such infrastructure and where the population has been steadily increasing over the last 5 years;
- Improve medical facilities by adding to the current facilities and improve the overall wellbeing amongst employees and their dependents with targeted health awareness programs, particularly for key issues such as malaria and HIV prevention;
- Provide opportunities for Zambian nationals to purchase housing through an affordable repayment scheme;
- Provide the Government of the Republic of Zambia with royalty payments and taxes;
- Significantly improve the balance of payments of the country for the life of the project;
- Improve the financial standing and reputation of Zambia as a good investment destination thus encouraging additional Foreign Direct Investment;
- Maintain an investment in mineral exploration in the region; and
- Provide economic benefits to Equinox Minerals Limited and its shareholders.

The number of expatriate personnel will be kept to a level to ensure a competitive international project and achieve specific training objectives to ensure Zambian employees maintain or reach this standard. ECV is committed to ensuring that in the longer term, the roles undertaken by expatriate personnel will be ultimately undertaken by Zambian nationals.

Wages spent in the local economy will have a multiplier effect on the demand for goods and services in the North West Province resulting in a benefit to the region's domestic product. Business and industry confidence in the region would be expected to improve as a result of a large project such as this being developed.

Exploration in the region would continue and it would be hoped that further economic mineral discoveries would be made and developed.

2.1 Alternatives Considered

As a component of this EIA, project alternatives have been considered for various aspects of the project. Comparative evaluations of mining development options are severely constrained by the fixed location of the mineralised zone and few mineral processing alternatives. However, project development alternatives were considered at the project pre-feasibility stage and some changes were made to the mine design in the course of completing the BFS and subsequent review of the BFS with the current proposal, which necessitated the consideration of alternative design options. A brief synopsis of these project alternatives is presented here.

Mining Methods

The extraction of ore from the Malundwe and Chimiwungo deposits can be achieved by underground or open pit mining methods. Underground mining has the positive environmental aspect of minimal surface disturbance. However, underground mining compared to open pit mining would be significantly more expensive at Lumwana due to the low grade of mineralisation, ore dilution, lower recovery, cost of mine fill and higher mine development costs. By contrast the ore body geometry i.e. shallow depth and dip, and resulting low stripping ratio is conducive to open pit mining. The decision to opt for an open pit mine was based purely on project economics. Underground mining at Lumwana is cost prohibitive.

Waste Rock Dumps

The location of the mine waste rock dumps is primarily a function of the tramming distance from the open pits to the dumps. At Malundwe, the waste rock dump is located close to the east side of the pit. No alternative sites are available within viable tramming distances and none were considered because the dumps did not pose a nuisance to local communities.

At Chimiwungo, the proposed sites for the waste rock dumps have again taken into account similar factors as above. Further consideration has also been giving to backfilling of Malundwe pit with Chimiwungo waste, although the economics of hauling waste rock that distance are not favourable. If areas become available in pits and mining has ceased, and further drilling has determined that sterilisation of the ore body is not an issue, strong consideration will be given to back filling of pits.

Metallurgical Processing

Sulphidic copper ore from the Malundwe and Chimiwungo deposits will be processed using conventional crush-mill-float technology to produce copper concentrate. This process uses proven technology that is well understood and in use worldwide. The ore types are not economically amenable to other process routes and none were considered. Further processing such as a roast-leach-elctrowin or smelting was considered but the economics impacted the project's viability.

Tailings Disposal

Sub-aqueous and in-pit tailings disposal were considered as options to the current plan to construct a dam in the river valley and divert the river. Whilst the options chosen, possibly increases the surface area of the TSF, it possibly represents the most environmentally sound disposal technique. The risks at closure and post-closure are greatly reduced.

Permanent Accommodation

The BFS considered four schemes for housing Company employees. These schemes are:-

Scheme A: All employees shall be housed in Solwezi and commute daily to and from Lumwana mine site;

Scheme B: Senior management and maintenance crew shall be accommodated at the mine site and the remaining employees commute from Solwezi; and

Scheme C: All employees shall be accommodated at the mine site on single status.

Scheme D: A fully contained town constructed on site facilitating home ownership for Zambian nationals.

The four schemes were reviewed and ranked on the following:

- Capital Cost;
- Operating Cost;
- Government Acceptance;
- Local Community Acceptance;
- On-call Maintenance Support;
- Employee Acceptance;
- Ecological Impacts;
- Sustainability of Lumwana Area;

- Operational Practicality;
- Capacity of Solwezi;
- Road Reliability/Safety Issues;
- Uncontrolled Development; and
- Broader Community Acceptance.

Whilst at the time of the BFS, Scheme A was the most preferred, social considerations and health and safety have been given more weighting and Scheme D is the preferred option.

No Project Option

Development of the Lumwana copper project will result in extensive physical disturbance of the land (approximately 41 sq.km), which for the most part is permanent. These physical environmental impacts include open pit mining operations, construction of waste rock dumps, plant site, tailings storage facility and the Lumwana East River diversion scheme. However, if well managed and appropriate reclamation measures implemented, these mine components will have minimal public health or safety risks and no long-term effects on adjacent watercourses or groundwater resources.

If the Lumwana copper project does not proceed there will be no disturbance of the environment. However, the no project option must be weighed up against the loss of a multi million dollar long-term investment for the Lumwana area, the North Western and Copperbelt Provinces of Zambia, and the whole Zambian economy. ECV will employ several thousands of people (directly and indirectly) during the life of the mine. There will be numerous flow on effects for the local and regional communities. Additional jobs will be created in service industries in the provincial capital Solwezi and in Copperbelt towns where the older copper mines are in decline. ECV is committed to local employment, the use of local contractors and the promotion of independent sustainable economic development in the Lumwana area.

The no project option will be a major setback for regional and national economic development.

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3. EXISTING ENVIRONMENT

3.1 Environmental Baseline Study

The Lumwana environmental baseline study was conducted over a 12 month period beginning in November 2001 and finishing in December 2002. A full 12 month data collection programme was undertaken to account for temporal and seasonal changes in site conditions. Some of these programs have continued since 2002 to further supplement the existing knowledge.

The baseline study area chosen for physical and ecological data collection is mainly that area which is in the direct zone of influence of the mine, its process facilities and infrastructure. Physical and ecological data was also collected on the Lumwana East River downstream of the immediate project area.

Project socio-cultural-economic impacts will affect a greater geographical area than the direct environmental impacts. The baseline study area for the socio-cultural-economic study corresponds to the extent of the rural community in which the project is located. The study area therefore roughly parallels the extent of His Royal Highness Chief Mukumbi's Chiefdom.

3.1.1 Scope of Work

The scope of work for the Lumwana baseline study included:

- A desk study of all available information on the project area;
- Visits to Government Departments, Non-Governmental Organisations and other relevant authorities.
- An investigation/assessment of environmental and social baseline conditions including:
  - Climate
  - Air quality
  - Topography
  - Geology
  - Hydrogeology
  - Hydrology
  - Aquatic flora and fauna
  - Terrestrial flora and fauna
  - Cultural and natural resources
  - Land use and land classification
  - Radiation survey
  - Noise and vibration
  - Infrastructure and communications
  - Social-cultural-economics

3.1.2 Baseline Team

The baseline study was undertaken by the following people:

- Mr Andrew Spivey - study co-ordinator and environmental engineer (AMC).
- Mr Mattias Fackel - Environmental Scientist (AMC).
- Mr Nyundo Armitage - Environmental Engineer (AMC).
- Mr Lishomwa Mulongwe - Principal Forestry Research Officer, Forestry Research Department, Ministry of Environment & Natural Resources, Kitwe.
- Mrs Esnart Chuba - Herbarium Scientist, Forestry Research Division, Kitwe.
- Mr Henry Kabunda - Senior Fish Culturist at the National Aquaculture Research and Development Centre, Ministry of Agriculture, Forestry & Fisheries (MAFF), Kitwe.

- Mr Denis Haambote - Archaeologist, National Heritage Conservation Commission (NHCC).
- Mr Jacob Chilufya - Geo-morphologist, National Heritage Conservation Commission (NHCC).
- Dr. Mutilo Silengo, Socio-cultural-economic Specialist (AMC).

3.2 Climate

3.2.1 Regional Rainfall, Temperature, Humidity and Sunshine Data

The North Western Province of Zambia lies predominantly between the elevation of 1,000 and 1,400m above mean sea level (amsl). The region has distinct dry (May to October) and wet (November to April) seasons. Rainfall mainly occurs in heavy thunderstorms producing typical precipitation events of 10 to 40 mm.

Department of Meteorology 30-year climatic data (1950 - 1980) for North Western Province towns of Solwezi (65 km east) and Mwinilunga (170 km west) indicates mean annual rainfall to vary between 1,100 and 1,400 mm per annum. Data for the period 1931 - 1960 indicates that annual rainfall of between 1,500 and 1,600 mm per annum can be expected one year in five in Solwezi and Mwinilunga respectively. Department of Meteorology rainfall charts indicate that rainfall of 1,400 mm per annum can be expected one year out of five in the area of the Malundwe and Chimiwungo copper deposits.

Extreme weather events such as floods, droughts and high winds do occur from time to time. The 30-year maximum storm event for Solwezi has been calculated as 126 mm and the 100-year maximum 24-hour event as 149 mm.

Mean annual humidity at Mwinilunga is recorded as 65 - 70%. Mean humidity levels vary from a minimum of 45% in the cool dry season to a maximum of 65% in the wet season. Humidity levels peak at 90% in October prior to the onset of the rains. No humidity data is available for Solwezi but the Mwinilunga humidity data is considered representative of the Lumwana area.

Mean annual sunshine in Solwezi and Mwinilunga is 2,500 to 2,600 hours.

Wind frequency data for Mwinilunga based on 5 years of daytime observations indicates that the prevailing dry season (July) wind direction is from the east to south east with mean and maximum wind speeds of 2.4 ms^{-1} and 9.2 ms^{-1} respectively. The mean number of calm days in July is 7.5. The prevailing wet season (January) wind direction is from the north and northwest with minimum and maximum wind speeds of 1.4 ms^{-1} and 6.7 ms^{-1} respectively. The mean number of calm days in January is 12.1.

3.2.2 Local Rainfall, Temperature and Wind Data

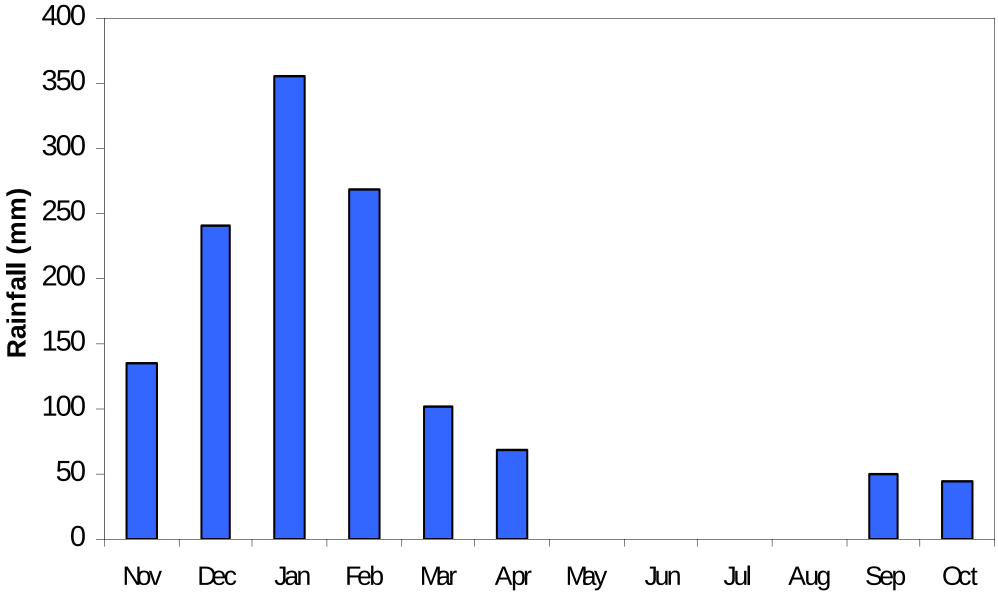
In 1998, a weather station was installed at the Lumwana exploration base camp situated approximately 16 km west of the Malundwe deposit. A continuous record of rainfall, temperature and wind data is available for September 1998 to December 1999. Lumwana climatic data for this period is summarised in Table 3-1. Temperature and rainfall for January to December 1999 is plotted in Figure 3-1.

Table 3-1: Meteorological Data - Lumwana Base Camp 1998/99

PARAMETER	DESCRIPTION	VALUE
Rainfall	Total annual	1,310 mm
Temperature	Maximum (daytime, October) Minimum (night-time, June)	34.2° 4.0°
Wind	Mean speed Maximum speed Prevailing wind direction	0.3 ms^{-1} 14.8 ms^{-1} Southeast

The total annual rainfall recorded at Lumwana Base Camp in 1999 was 1,310 mm. Of this, 1,228 mm or approximately 94% fell between November and March. Total rainfall during the period (November 2001 - October 2002) was 1,265 mm, with 87% of the rainfall falling between November and March. Figure 3-2 shows monthly rainfall at Lumwana Camp from November 2001 to October 2002. The highest amount of rainfall on any single day occurred on the 1st of January 2002 and was recorded as 100 mm.

Figure 3-1: Rainfall Data – Lumwana Base Camp 2001/02



3.3 Air Quality

No air quality data is available for the Lumwana area because of its remoteness and the absence of industry and infrastructure. Field observations indicate that the general air quality in the area is good. However, seasonal variation as well as localised and temporal deterioration in air quality does occur.

Grassland and forest fires, charcoal burning and traditional *Chitemene* slash and burn agriculture during the dry season generates smoke and dust. This air pollution hangs over the area and forms a distinctive haze. The haze layer is mainly visible from the air and worst during the coolest months (June and July) when temperature inversions tend to trap the smoke near ground level. The haze lasts until the arrival of the rains in November. Localised and temporal air quality deterioration is also associated with village domestic fires.

Field observations indicate that exhaust emissions from vehicles travelling along the T-5 main road disperse rapidly and are very localised. Current road traffic volumes are low at 2.35 pick-up vehicles per hour and 2 - 3 trucks/buses per day (refer to ECV Lumwana Road Traffic Survey, June 2001, Appendix I).

3.4 Topography and Landform

Topography in the project area, shown on Figure 3-4, is dominated by gently rolling hills formed by the erosion of the upland plateau and defined by the drainage pattern of the Lumwana East River and its tributaries. The Malundwe and Chimiwungo copper deposits take their names from streams, which pass close to or over the deposits.

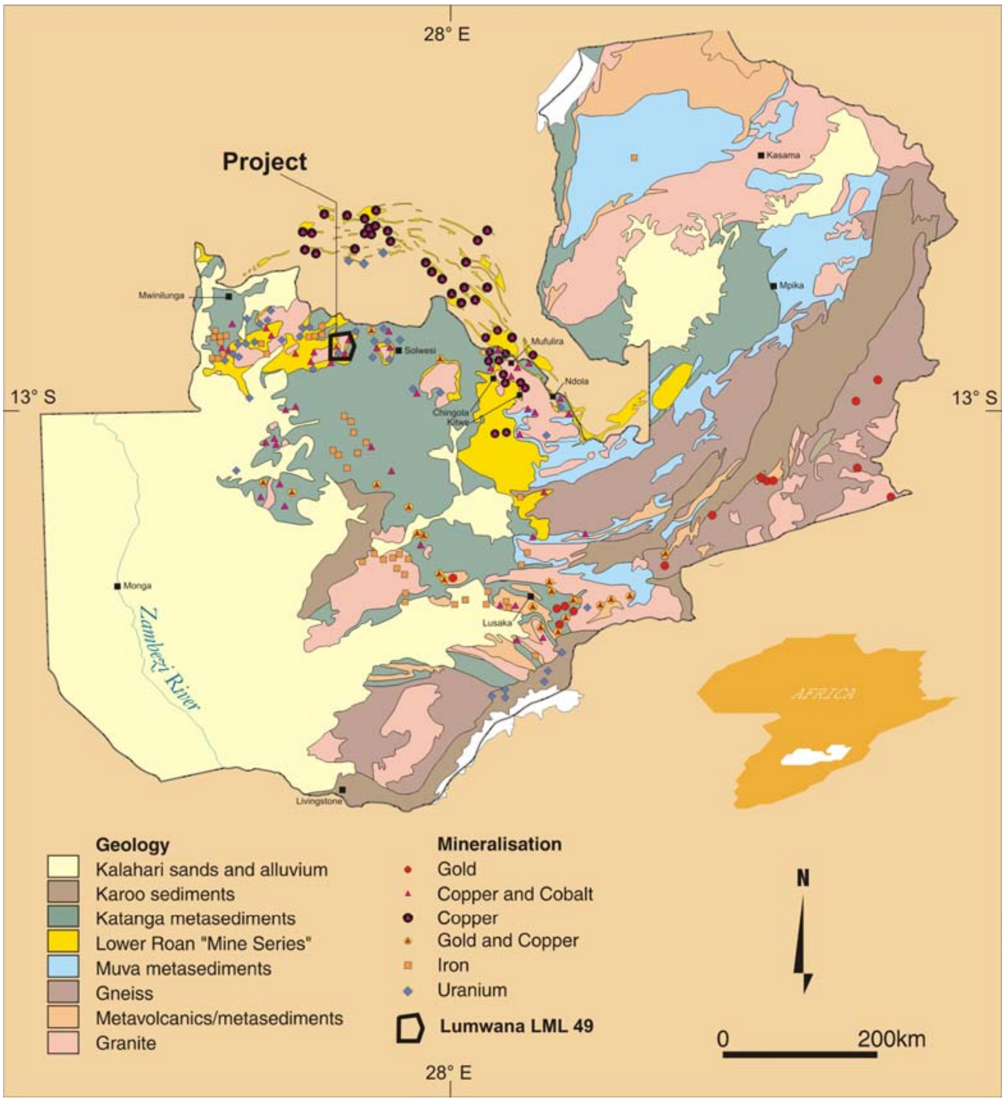
Surface elevations in the vicinity of the Malundwe copper deposit vary between 1,280 and 1,380 m amsl while at the Chimiwungo copper deposit, elevations vary between 1,340 and 1,380 m amsl. The highest point in LML-49 is 1,532 m amsl occurring on the northern boundary. Although there is little discernible difference in altitude across the immediate project area, many of the watercourses flow through deeply incised valleys. In forested areas away from rivers and streams, slopes are gentle with gradients of between 1.5 and 3.0%.

3.5 Geology

3.5.1 Regional Geology

The regional geology of the Copperbelt area is shown in Figure 3-2.

Figure 3-2: Zambia – Copperbelt Regional Geology



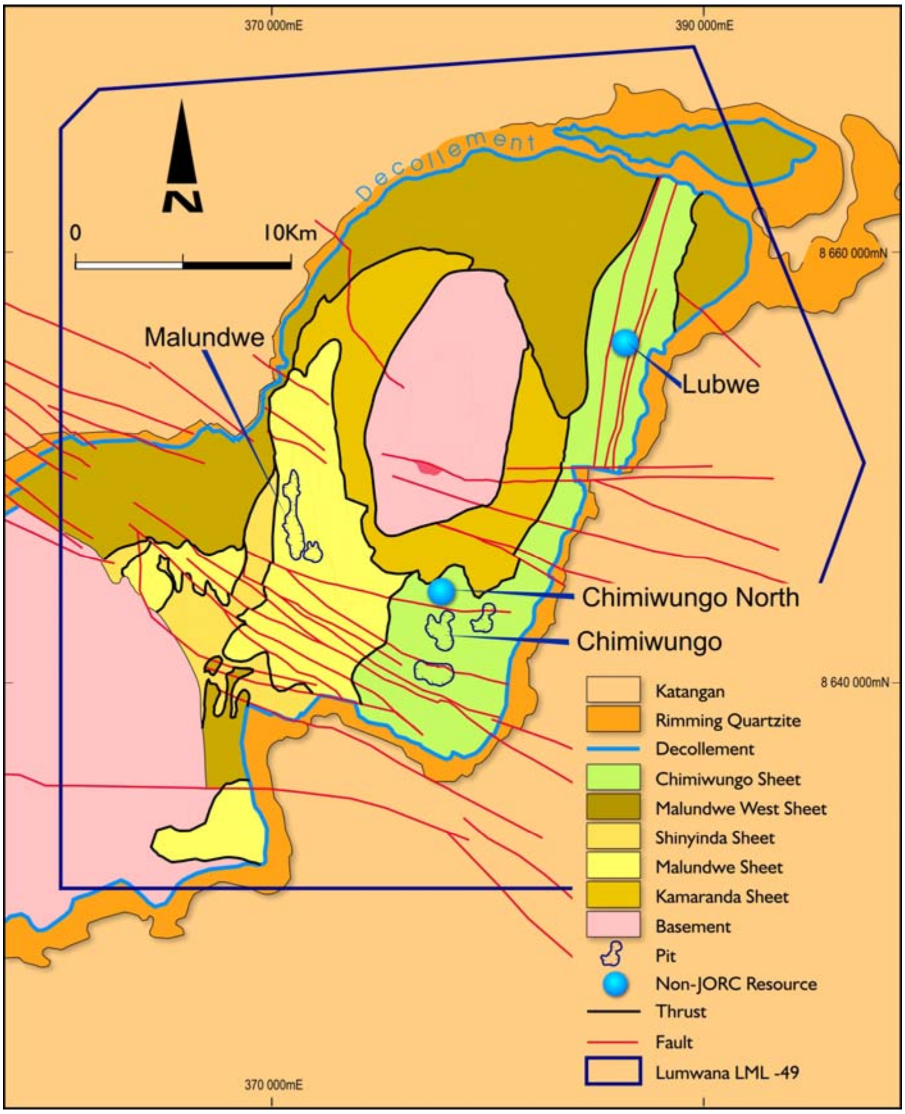
The Lumwana deposits of Malundwe and Chimiwungo are hosted within the Mwombezhi Dome, which is a northeast trending basement dome in the western arm of the Neoproterozoic Lufilian Arc thrust fold belt. The Lufilian Arc is a major tectonic province characterized by broadly north-directed thrust structures and antiformal Basement inliers or domes surrounded by Katangan metasediments which host the Central African Copperbelt.

There are a number of known mineral occurrences in the area. Emerald, amethyst, gold, uranium, copper, cobalt and sodalite are reported on the "Geological and Mineral Occurrence Map" (Geological Survey Department, 1994).

3.5.2 Geology of the Malundwe and Chimiwungo Copper Deposits

Figure 3-3 shows the local geology with respect to the Malundwe, Chimiwungo, Chimiwungo North and the less understood Lubwe deposits. The first three deposits have Australasian JORC Code/Canadian NI 43-101 compliant resource. Lubwe has a non-JORC/NI 43-01 resource defined by Roan Selection Trust in 1968 which will not be considered further in this report.

Figure 3-3: Lumwana Copper Project – Local Geology



The copper mineralisation at Lumwana occurs as disseminated coarse-grained sulphides hosted within biotite-muscovite-kyanite-quartz schist, referred to as the Ore Schist, which exhibits a strong N-S stretching lineation and an intense shear fabric. The Schist is interpreted, to have been formed in a major shear zone. The hanging wall to the Ore Schist is a sequence of pink to grey quartz-feldspar-biotite gneisses to schists, which stratigraphically underlie Lower Roan quartzites and carbonates flanking the Mwombezhi Dome and are dated as pre-Katangan (Cosi et al, 1992). The footwall to the Ore Schist varies between the three deposits. At Malundwe it consists of various kyanite-mica-quartz schists passing into a generally sheared micaceous quartzite to muscovite-quartz schist (Footwall Quartzite). This lithology is interpreted to be either basal Lower Roan or a hybridised and metasomatised tectonic mélange composed of both Lower Roan Basement lithologies. The Footwall Quartzite overlies a sequence of altered and brecciated Upper Roan Dolomites and calcsilicates intruded by amphibolites.

At Chimiwungo and Chimiwungo North the footwall consists of dominantly grey sometimes amphibolitic quartz-feldspar-biotite gneisses to schists with interbands of kyanite-mica-quartz schists.

The mineralisation at Malundwe extends for approximately 6.0 km in the north-south orientation and up to 1.5 km wide (east-west). The mineralisation outcrops at surface to the east, and extends to maximum depth of approximately 200 m below surface to the west and south and is open to the south. The Ore Schist is tabular to gently folded, has an average thickness of 14 meters, (ranging from 1 to 70m) and dips gently to the west at between 10° and 20° and plunges to the south at around 15°.

Chimiwungo Main (including Chimiwungo East) mineralisation extends 1.5 to 2.4 km north-south, and 4.2 km in the east-west orientation, extending to approximately 460 m below surface down dip and down plunge to the south. At its southern limit the Chimiwungo Main deposit is truncated by the Chimiwungo South Fault.

Chimiwungo South is the up faulted continuation of the Chimiwungo Main mineralisation. The mineralisation extends up to 1 km north-south, open to the south and east and 1.7 km in the east-west orientation, extending to the limit of drill definition at approximately 370 m below surface to the south and east.

Chimiwungo North is very similar in style to Chimiwungo being the northern extension of the Chimiwungo deposit, which has been down faulted by approximately 80m by the Chimiwungo North Fault Zone. This fault zone is similar in style to the Chimiwungo South Fault and consists of 2 major splays, which hosts some mineralisation. The orebody consist of a single, 5 -10^o south dipping zone, up to 60m thick, currently extending over an area of 800m N-S by 500m E-W.

In summary the Malundwe, Chimiwungo and Chimiwungo North tectono-stratigraphy can be considered a highly sheared and altered tectono-stratigraphic sequence produced by major D1 Shear zone thrusts. The Ore Schists and the Footwall Quartzite/Muscovite-Quartz Schist units appear to be the most strongly sheared and metasomatically altered portions of the shear zone. Both deposits contain lenses (Malundwe) or internal horizons (Chimiwungo) of quartz-feldspar – biotite gneiss to schist, similar to the Hanging wall Gneiss. This suggests the Ore Schist was not a different lithology, but instead a hybrid tectonic rock produced by intense Lufilian age shearing and alteration of the Basement Hanging Wall Gneiss just below the Basement – Katangan contact.

The Malundwe, Chimiwungo and Chimiwungo ore contains typically 5% sulphides dominated by copper-iron sulphides. Typically sulphide assemblages are:

- Chalcopyrite (CuFeS2) - Pyrite (FeS2);
- Chalcopyrite (CuFeS2) - Bornite (Cu5FeS4);
- Chalcopyrite (CuFeS2) - Pyrrhotite (FeS) - Cubanite (CuFe2S3); and
- Chalcocite (Cu2S) - Bornite (Cu5FeS4).

Malundwe has all four assemblages but is dominated by the Chalcopyrite – bornite assemblage. Chimiwungo has all except the Chalcocite – Bornite assemblage but is dominated by the Chalcopyrite – Pyrite and Chalcopyrite - Pyrrhotite – Cubanite assemblages. Barren rocks are commonly enriched with iron. Nickel is associated with the more pyritic zones of the ore bodies. High cobalt concentrations are related to carrolite (Cu (Co,Ni)2 S4) enclosed in chalcopyrite, cobalt pentlandite (Fe,Ni,Co)9S8 and cobaltiferous pyrrhotite hosted predominantly in the Upper and Main Ore Schist units at Chimiwungo. Gold and uranium are present as discrete zones mainly within the Malundwe Ore Schist or immediate footwall, although sporadic zones of uranium and gold mineralisation are observed at Chimiwungo.

3.5.3 Lumwana Insitu Mineral Resources

The Lumwana resource estimates were classified in accordance with the Australian Code for Reporting of Identified Mineral Resources and Ore Reserves (“JORC”) and the Canadian NI 43-101 Standards. The estimates are based upon data compiled by S Khosrowshahi, Principal Ore Reserve Specialist (Golder) and M Richards, Equinox Minerals - Exploration Manager Africa. The total resource (including Chimiwungo North) is 944.8 Mt at 0.69% Cu.

The JORC/NI 43-101 compliant total Lumwana uranium resource is 12 million tonnes grading at 695 ppm uranium which is a relatively low grade by world standards.

Table 3-2 shows the total copper, cobalt and gold resources for the combined Malundwe and Chimiwungo deposits stated to JORC/NI 43-101. A 0.2% cut-off grade is used for reporting the copper, cobalt and gold resource. The uranium resource is reported independent of the copper, cobalt and gold, using a 100 ppm uranium cut-off grade and is shown in Table 3-3. Table 3-4 shows the total copper resources for the Chimiwungo North deposit discovered since the mine plan was developed. This resource is currently not within mine plan; after further exploration, should it prove economic, approvals to develop will be sought.

Table 3-2: Lumwana Copper, Cobalt and Gold Resource (at 0.20% Cu Cut-Off)

Class	Tonnes (Mt)	Cu (%)	Co (ppm)	Au (g/t)
Measured	129.4	0.89	238	0.03
Indicated	140.0	0.78	187	0.02
Total (Measured and Indicated)	269.4	0.83	212	0.02
Inferred	631.8	0.64	51	0.01

Table 3-3: Lumwana Uranium Resource at 100 ppm U Cut-off

Class	Tonnes (Mt)	U ppm
Indicated	9.5	788
Inferred	2.6	355
Total Resource	12.1	695

Table 3-4: Chimiwungo North Total Copper Resource (at 0.20% Cu Cut-Off)

Class	Tonnes (Mt)	Cu (%)	Co (ppm)	Au (g/t
Measured	0	0	N/E	N/E
Indicated	34.38	0.50	N/E	N/E
Inferred	9.19	0.42	N/E	N/E
Total (Indicated and Inferred)	43.57	0.49	N/E	N/E

N/E = Not Estimated

3.5.4 Seismic Activity

According to the Seismic Hazard Map of Africa (G. Grünthal, C. Bosse, Geoforschungs Zentrum, Potsdam, Germany) there is a 10% probability of a peak ground acceleration of between 0.4 and 0.8 m/s^2 being exceeded every 50 years in the North Western Province of Zambia. Seismic events of magnitude 4.9 on the Richter scale have been recorded in the Province (Turyamurugyendo - Seismic Hazard Assessment in Eastern and Southern Africa, 1996). Lumwana is considered to be an area of low to medium seismic activity.

3.6 Hydrogeology

3.6.1 Hydrological Model

Golder undertook a hydro-geological assessment in the Malundwe and Chimiwungo deposits as part of the project feasibility study in October and November 2002. The study included borehole pumping tests to estimate aquifer transmissivity and storage.

The hydrogeological assessment concluded that groundwater flows, across the Malundwe

Deposit are regionally controlled by the pervasive, slight to moderate fracturing that occurs in the fresh hanging wall gneiss, ore and footwall schists; and the second porosity developed within the epidote schist.

However, the results from the test pumping programme show that locally, groundwater flow regimes are dominated by the inferred highly permeable fracture zones, possibly related to jointing. The most significant of these fracture zones is an E-W trending zone, which is coincidental with the Lumwana East River valley.

Drilling at Chimiwungo identified no highly permeable fracture zones and it is surmised that groundwater flows will be predominantly through the pervasive, slight to moderate fracturing within fresh hanging wall gneiss, ore schists and footwall units.

Groundwater modelling was carried out to estimate likely dewatering rates during mining. The aquifer parameters adopted for the modelling are summarised below:

- General rock mass (Malundwe and Chimiwungo Deposits) - hydraulic conductivity 0.005 to 0.05 m/d, specific yield 0.001.
- Fracture zones within the Lumwana East River valley (Malundwe Deposit) – hydraulic conductivity 0.05 to 10 m/d, specific yield 0.0001 to 0.001.
- Fracture zones in the interfluve areas (Malundwe Deposit) – hydraulic conductivity 0.1 m/d, specific yield 0.001.

The model predicted dewatering rates for the Malundwe Pit ranging from 7,000 to 25,000 m^3/d in the last year of mining at the deposit. For the Chimiwungo Pits the estimated total dewatering rates vary between 2,000 and 5,000 m^3/d at the start of dewatering in year 5 to between 24,000 and 85,000 m^3/d at the completion of mining.

3.6.2 Groundwater Quality

Groundwater is used extensively in the project area for domestic and potable water. Since 1990, the Department of Water Affairs has sunk many wells along the T-5 main road to supply villages with clean domestic water. The closest well to the Malundwe copper deposit is in Mafuta village approximately 4.5 km to the south of the deposit.

Historical Groundwater Quality Data

Steffen, Robertson & Kirsten (SRK) Consultants sampled groundwater on 4 occasions in 9 exploration drill holes in the Malundwe copper deposit between December 1994 and February 1996.

Groundwater analyses indicated relatively high conductivity values and elevated concentrations of iron, sulphates, manganese and nitrates, all of which exceeded South African groundwater quality standards. The natural oxidation of sulphide minerals and subsequent leaching and release of elements and salts in solution has resulted in relatively high groundwater conductivity values within and close to the deposit. Corrosion of old drill hole casings may have affected the quality of the groundwater samples.

Golder sampled groundwater from 3 drill holes in the Malundwe deposit in 2000. Chemical analyses of these water samples confirmed that oxidation of sulphide ore was affecting groundwater quality locally. However, alkaline mafic silicate minerals present in the host rocks act as a buffer to acid generation, resulting in neutral groundwater pH. Groundwater samples collected in February 2000 were all typical of calcium carbonate and calcium chloride type water with significant concentrations of magnesium. Nitrate, nitrite and metal concentrations were low or below detection limits. Seasonal variations in salinity were considered of less importance than variations observed between sites. \

Chemical analyses of groundwater samples from wells at Mafuta village indicated that the drinking water was generally of good quality, although a pH of 5.8 was recorded in one well. No metals were detected apart from zinc at a concentration of 0.46 mg/l. One well had a relatively high TDS level due to the presence of calcium, magnesium, potassium and sodium. The pH of the groundwater was generally neutral and metals were below detection limits.

As part of the baseline study, artesian drill hole MAD-053 in the Malundwe copper deposit was sampled monthly from November 2001 to December 2002. This drill hole was also sampled by SRK in 1994. The analytical results for samples collected by AMC (Dec 2001) and SRK (Dec 1994) for the parameters pH, conductivity, sulphate and magnesium are compared in Table 3-5. The data shows an increase in conductivity, sulphate and magnesium concentrations between 1994 and 2001. Field measurements of conductivity also showed a similar increase over time. Field confirmation of laboratory conductivity values suggests that the difference in MAD-053 groundwater quality between Dec 1994 and Dec 2001 is most likely due to oxidation of sulphide minerals and/or extended drill hole casing corrosion rather than sample storage, transportation or laboratory analysis.

One further groundwater sample was taken in October 2002 from a 1m pit excavated in the Chimiwungo Dambo. This sample was taken in order to evaluate the composition of groundwater associated with the Chimiwungo dambo, which discharges into the Chimiwungo stream. The location of the Pit was 100m north of the Chimiwungo Bridge, within the weathered hanging wall and into the upper ore schist of the Chimiwungo deposit (UTM E 377799, N 8642335).

Table 3-5: Comparison of Groundwater in Drill Hole MAD-53, SRK 1994 & AMC 2001

Drill Hole MAD-53	**Analytical / Field Parameters**				
	PH	**Conductivity µS/cm**	**Field Cond. µS/cm**	**Sulphate mg/l**	**Magnesium mg/l**
SRK 20/12/94	7.3	1,340	1,300	862	61
AMC 03/12/01	7.4	1,700	1,600	910	97

Tables 3.6 a and b present the mean parameter values (4 monitoring occasions between 1994 and 1996) for environmental monitoring conducted by SRK in and around the Malundwe and Chimiwungo deposits.

Baseline Groundwater Monitoring

The groundwater sampling protocol is described in Appendix J. Analytical parameters are the same as those for baseline surface water sampling described in Section 3.7.6. Full results of groundwater analyses and field quality measurements are presented in Appendix K.

Malundwe Exploration Drill Hole MAD 53 - Sampling Location Lum/GW-01

The following metals were below detection limits i.e. <0.1 mg/l at Lum/GW-01 from November 2001 to October 2002: arsenic, barium, beryllium, chromium, manganese, mercury, vanadium, nickel, selenium and zinc. Metals present in detectable concentrations included: aluminium, boron, iron, lead and uranium.

The mean concentration of aluminium in groundwater at Lum/GW-1 was 0.15 mg/l. Cadmium and Molybdenum were below detectable limits except for recorded concentrations at the detection limit (0.01 mg/l and 0.1 mg/l) in samples collected in November 2001 and October 2002. Boron was recorded at 10 mg/l in November 2001 but was below detectable levels throughout the rest of the sampling period. Cobalt and copper were also below detectable limits except for cobalt 0.9 mg/l in October 2002 and copper 0.7 mg/l in June 2002. Iron was recorded at 0.5 mg/l in February and May 2002, but was otherwise below detection limits. Magnesium concentrations in groundwater were relatively high with a maximum value of 97 mg/l recorded in November 2001 and a mean concentration of 47.5 mg/l over the 12 month monitoring period. Relatively high lead concentrations of 0.03, 0.1, 0.2 and 0.1 mg/l were recorded in June, August, September and October 2002 respectively. Uranium was recorded at 0.4 mg/l in November 2001 and June 2002 but was otherwise near or below detectable limits (<0.1 mg/l).

Neutral groundwater pH values were recorded from November 2001 to October 2002. Mean conductivity was 1,580 µS/cm with a peak conductivity of 1,778 µS/cm recorded in July 2002 and a low conductivity of 1,083 μS/cm recorded in June 2002. Mean TDS was also relatively high with an average value of 1,362 mg/l. Mean sulphate was relatively high at 890 mg/l as were the parameters chlorine and calcium with mean concentrations of 11 mg/l and 113 mg/l respectively. Mean TSS was predictably low at 11 mg/l.

Table 3-6a: Results[*1] of Groundwater Analysis at Malundwe (SRK, 1996)

Parameter	Bore Number							
	MMB 115	MMB 535	MMB 620	MAD 46	MAD 53	MAD 127	MAD 174	MAL 4
pH	7.1	6.8	6.6	7.3	7.3	7.4	6.5	6.9
EC (μS/cm)	1873	380	349	1497	1480	1058	204	281
$CaCO_3$ (mg/L)	106.7	180	93	107	106	114	91.3	136.7
Ca (mg/L)	448	43	37	303	215	184	18.8	25
Mg (mg/L)	47	12	13.5	50.7	68	33.2	4.1	14.5
Na (mg/L)	29.7	9.1	9.8	22	23	23.5	9.7	7.43
K (mg/L)	15.3	12.5	5.8	12.6	14.9	12.0	4.9	6.6
SO_4 (mg/L)	1231	11.3	72.7	892.3	904.7	519.2	3.0	2.7
Cl (mg/L)	32.5	4.1	3.8	6.9	6.9	5.1	2.4	4.1
F (mg/L)	0.4	0.2	0.4	0.4	0.5	0.5	0.2	0.2
NO_3 (mg/L)	0.3	0.3	0.2	0.4	0.3	0.3	0.3	0.2
Fe (mg/L)	BDL	BDL	BDL	0.1	0.14	BDL	2.1	BDL
Mn (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cu (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Co (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Pb (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Zn (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
As (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Hg (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
U (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

**1 = Results are expressed as mean data based on sampling 1994 - 1996*
BDL = Below Detection Limit

Chimiwungo Test Pit - Sampling Location Lum/GW-02

Analysis of shallow groundwater collected from the dambo area (Lum/GW-02) within the footprint of the Chimiwungo deposit in October 2002 indicated a pH of 4.5, conductivity of 35 μS/cm and TDS, TSS and sulphate concentrations of 70, 14 and <5 mg/l respectively.
Metal analyses detected cadmium (0.02 mg/l) and lead (0.1 mg/l). Arsenic and barium were below detection limits. Copper, cobalt and iron concentrations were 0.1, 0.7 and 0.5 mg/l respectively.

<u>Conclusions</u>

Groundwater quality in the area draining the Malundwe deposit is characterised by relatively high conductivity and high TDS and sulphate concentrations. The ingress of groundwater into surface watercourses is affecting surface water quality as indicated by Lum/SW-09 monitoring data. However, the quantity of groundwater flowing into the main streams is diluted by surface runoff and/or groundwater discharge from groundwater systems not associated with the Chimiwungo and Malundwe deposits, which are likely to have lower element concentrations. The groundwater sampled from drill hole MAD 53 (Lum/GW-01) exceeds Zambian Drinking Water Standards for TDS, sulphate and on occasion aluminium, cadmium and lead, which possibly may be a result of corroding casing.

The shallow groundwater in the Chimiwungo Dambo area does not appear to be affected by the deposit. This is likely due to the nature of the dambo, which is characterised by a low permeability top horizon of clayey/organic material underlain by a horizon of sandy materials. The shallow groundwater sample collected from the test pit at Lum/GW-02 arose from the top layer of the dambo, which retains surface water. The slightly acidic pH value of 4.5 is likely the result of the decay of organic matter. The October 2002 pH, lead and cadmium concentrations exceeded the Zambian Drinking Water Quality Standards. The elevated metal concentrations are possibly reflective of the water acidity.

Table 3-6b: Results[*1] of Groundwater Analysis at Chimiwungo (SRK, 1996)

Parameter	Bore Number					
	CHI 19	CHI 21	CHI 23	MMC 158	MMC 185	MMC 473
pH	6.3	7.0	6.9	6.9	6.4	7.0
EC (µS/cm)	123	324	165	557	24	272
Alkalinity $CaCO_3$ (mg/L)	59	162	70	241	13	110
Ca (mg/L)	10	26	12	67	3.7	12
Mg (mg/L)	1.8	6.5	2.0	2.3	0.9	2.1
Na (mg/L)	9.8	32	10	4.3	3.5	45
K (mg/L)	4.2	7.6	14	47	0.6	2.4
SO_4 (mg/L)	8.2	3.7	4.0	11	2.6	24
Cl (mg/L)	4.3	5.6	5.3	7.2	Q3.7	4.5
F (mg/L)	0.2	0.5	0.3	0.2	0.1	0.5
NO_3 (mg/L)	0.1	0.7	0.4	7.6	0.3	0.3
Fe (mg/L)	12.9	BDL	BDL	0.3	BDL	BDL
Mn (mg/L)	0.7	0.6	0.2	0.2		
Cu (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL
Co (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL
Pb (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL
Zn (mg/L)	BDL	BDL	BDL	8.4	BDL	BDL
As (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL
Hg (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL
U (mg/L)	BDL	BDL	BDL	BDL	BDL	BDL

**1 = Results are expressed as mean data based on sampling 1994 - 1996*
BDL = Below Detection Limit

3.7 Hydrology

3.7.1 Introduction

The 12-month baseline hydrology study began in November 2001 and was completed in October 2002.

The objectives of the hydrology study were to:

- Describe the hydrology of the project area;
- Establish baseline surface water and groundwater quality in the zone of influence of the Lumwana Copper Project;

- Establish baseline flow rates in the rivers and streams of the project area; and
- Establish baseline element concentrations in rivers and stream sediments.

The scope of work included:

- A desk study to review existing hydrological data;
- A review of ECV's stream flow rate measurement methods and protocol;
- Collection of monthly surface water and groundwater samples at selected monitoring sites for physical, chemical, bacteriological, and total and dissolved metal analyses;
- Perform field water quality measurements on surface water and groundwater;
- Implementation of a river and stream flow rate measurement programme; and
- Collection of stream sediment samples for baseline geochemical analyses.

3.7.2 Surface Water Drainage

The general topography of the Lumwana area slopes from East to West (refer to Lumwana Topographic Plan - Figure 3-4). The Lumwana East River flows across the southern part of the Malundwe copper deposit, and drains the entire project area. Two tributaries of the Lumwana East River also interact with the Lumwana copper deposits. These are the Malundwe Stream (Malundwe deposit) and the Chimiwungo Stream (Chimiwungo Deposit). The Malundwe Stream flows in a southerly direction on the west side of the Malundwe deposit. This stream receives surface runoff from the deposit. Field observations made in mid-November 2001 indicate that groundwater contributes significantly to the stream's base flow during the dry season. The Chimiwungo Stream flows in a northwest direction across the central portion of the Chimiwungo deposits. The Lumwana East River is a tributary of the Mwombezhi River, which in turn flows into the Kabompo River and is a part of the major Zambezi River System.

The rivers and streams of the Lumwana area are perennial in nature. The project area lies approximately 30 kilometres downstream from the source of the Lumwana East River. In the vicinity of the project the Lumwana East River is a young river and its drainage pattern is controlled by local topography. The average gradient of the river in the project area is 0.4%. Its tributaries have a dendritic drainage pattern. The confluence of the Lumwana East and Mwombezhi Rivers is approximately 35 km downstream from the Malundwe deposit. From this point downstream, the river starts to meander and enter its mature stage.

3.7.3 Watercourse Catchment Areas

The catchment area of the Lumwana East River upstream of the T-5 main road bridge (monitoring site Lum/SW-03) is estimated to be 68,380 hectares. The river and stream catchment areas shown on Figure 3-5 are defined by surface water monitoring sites and watersheds.

3.7.4 Surface Water Usage

Potable water supply in the area is mainly derived from groundwater sources. For example, at Mafuta village (4.5 km south of the Malundwe copper deposit) potable water is derived from three large diameter wells. Small formal settlements tend to use surface water for domestic purposes. However, the Lumwana East River does not come into contact with any significant settlements downstream of the Lumwana copper deposits.

Surface water is used mostly for irrigation. Hand dug irrigation channels were observed in the area fed by flood drainage. Surface irrigation water is sometimes supplemented with artesian groundwater due to the presence of a high water table and perched ground water. Cultivations in dambo areas (commonly maize and garden vegetables) are irrigated from the dambo streams.

Figure 3-4: Topographic Plan of the Project Area

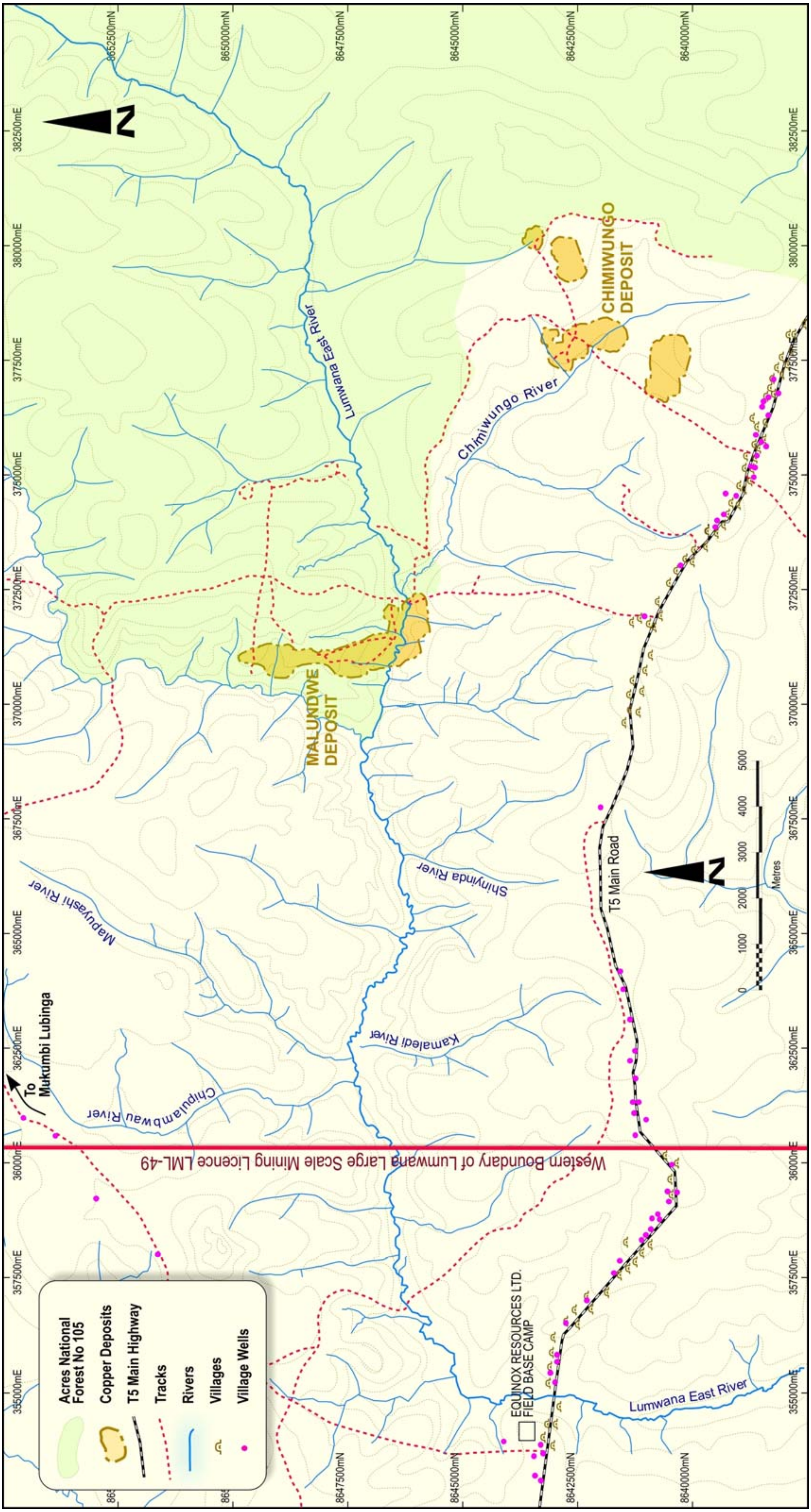
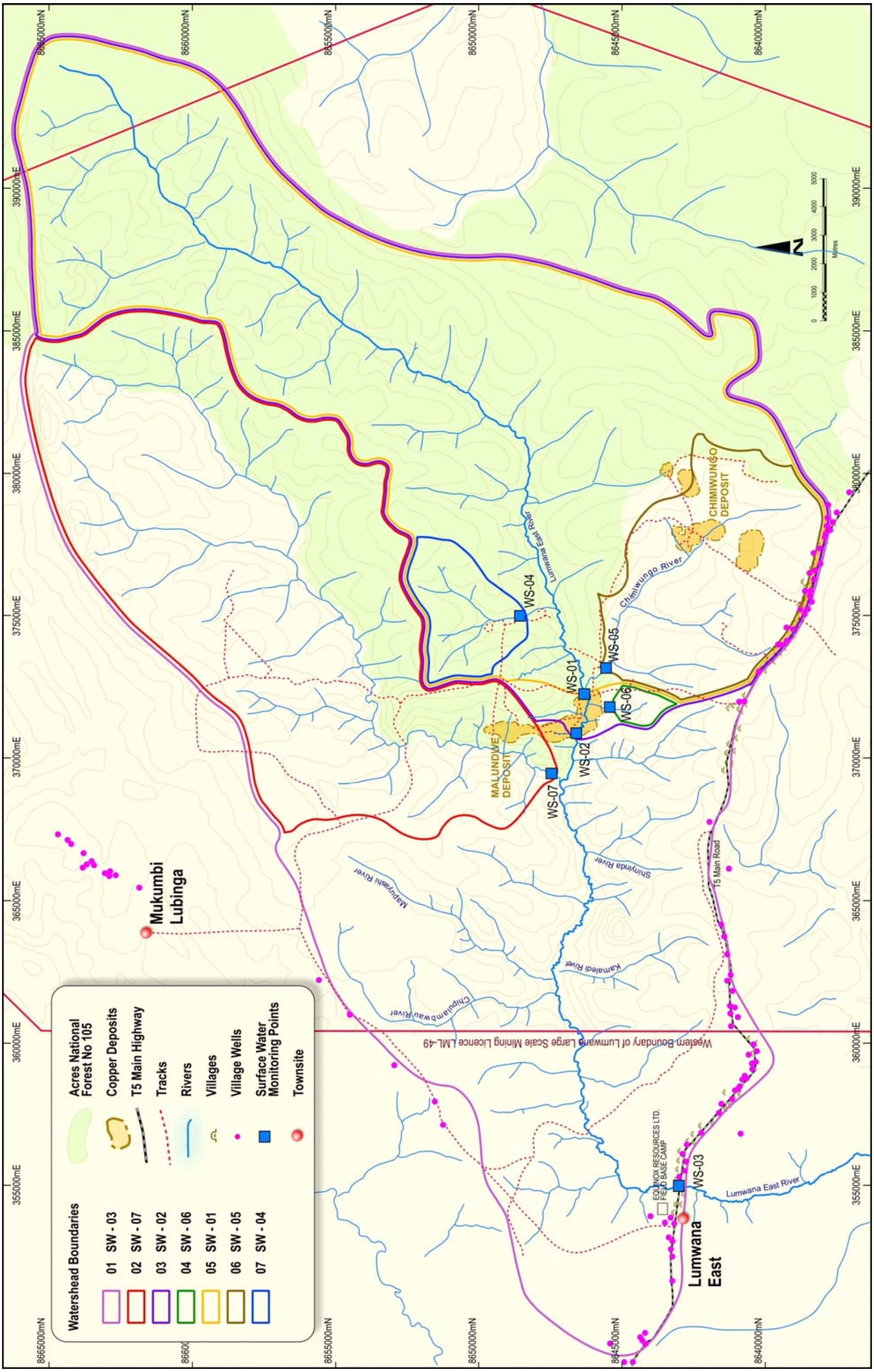


Figure 3-5: East Lumwana River and Tributary Stream Catchment Areas



3.7.5 Surface Water Character

Stream flow rate measurement and surface water quality analysis has been conducted in the project area prior to this baseline study. Phelps Dodge began monitoring stream flow rates in November 1993. SRK consultants monitored water quality at four sites and measured stream flow rates at three sites during a 16-month hydrology study commencing in October 1994. Weirs, gauge poles and channel profiles were used to measure water flows.

Golder conducted surface water sampling at 4 sites during a pre-feasibility site reconnaissance visit in November 2000. Table 3-7 describes the location of coincident past and current surface water monitoring sites.

Table 3-7: Coincident SRK, Golder and AMC Surface Water Monitoring Sites

Monitoring Sites			Physical Location
SRK 1994-96	Golder 2000	AMC 2002	
SRK 1	GA 4	Lum/SW-03	T-5 Main road bridge crossing over Lumwana East River near Lumwana Base Camp.
SRK 2	GA 1	Lum/SW-01	Lumwana East River, downstream of confluence with the Chimiwungo Stream.
SRK 3		Lum/SW-07	Chimiwungo Stream, upstream of confluence with the Lumwana East River.
SRK 4			Lumwana East River, downstream of confluence with the Malundwe Stream.

3.7.6 Surface Water Monitoring Programme

Monitoring Station Coverage

Seven representative water monitoring sites were chosen to evaluate the baseline surface water quality and river/stream flow rates in the project area. Two additional sampling points were chosen for evaluation in September and October 2002. The surface water monitoring sites are shown on Figure 3-6. The letters SW indicate the surface water monitoring sites. The co-ordinates of the monitoring sites and physical locations are described in Table 3-8.

Sites were selected on the basis providing baseline values of water quality against which the significance of future impacts can be measured. The results also provide the basis for the design of a mine environmental monitoring programme.

Sampling Frequency

A monthly surface water monitoring frequency was adopted. Monthly monitoring is considered practical and adequate to monitor seasonal variations in surface water quality.

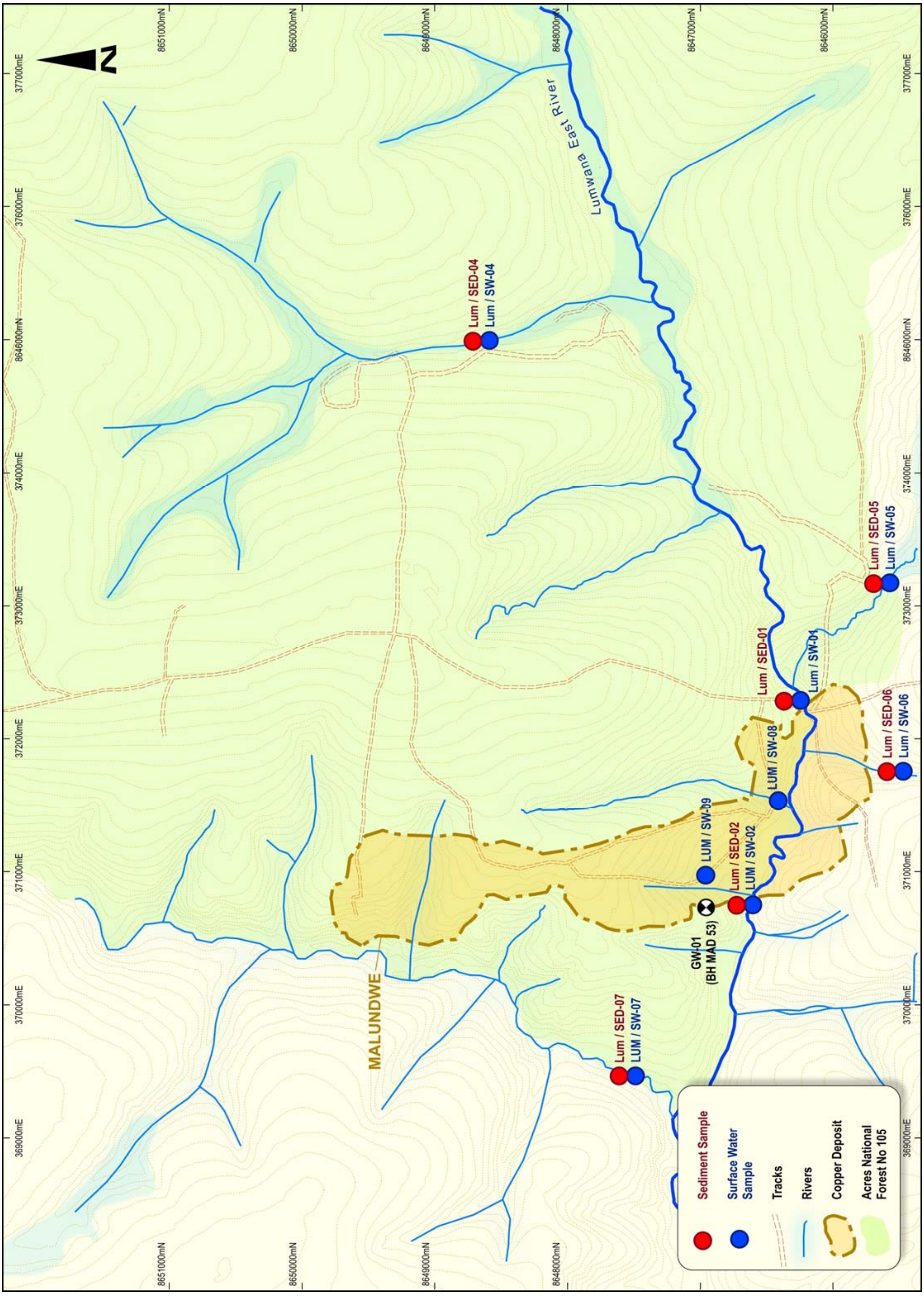
Full suite chemical, physical and bacteriological analyses were performed on surface water samples on a quarterly basis. Key parameters were analysed monthly.

River and stream flow rate measurements were carried out monthly using the stream velocity multiplied by cross sectional area method in the Lumwana East River and dilution gauging in smaller streams. There are no 'V' notch weirs or other flow rate monitoring structures in the streams and installation was not feasible during the wet season at the start of the baseline study.

Analytical Parameters

The main objective of the surface water sampling and analysis was to establish the pre-mining water quality in the rivers and streams of the project area. The results provide baseline values of water quality against which the significance of any future impacts can be measured. The results also provide the basis for the design of a mine environmental monitoring programme.

Figure 3-6: Surface Water and Ground water Monitoring Sites and Stream Sediment Sampling Sites



A range of physical, chemical and bacteriological parameters were included in the analysis program.

Monthly parameters were selected after reviewing the results of initial sampling (November 2001). These samples are likely to have the highest parameter concentration because sampling was done at the end of the dry season when stream levels are lowest. Monitoring sites Lum/SW-08 and Lum/SW-09 sampled in September and October 2002 were analysed for iron and sulphate in addition to the standard monthly analyses.

Table 3-8: Baseline Surface Water Monitoring Sites, Co-ordinates and Physical Location

Monitoring Site	Site UTM Co-ordinates		Physical Location
	Easting	Northing	
Lum/SW-01	372235	8646296	Lumwana East River, upstream of the Malundwe deposit and downstream of the confluence with the Chimiwungo Stream.
Lum/SW-02	370876	8646644	Lumwana East River, at western boundary of Malundwe copper deposit.
Lum/SW-03	354958	8643150	Lumwana East River at T-5 main road bridge crossing about 20 km downstream of the Malundwe copper deposit.
Lum/SW-04	375000	8643542	Kababisa Stream, a tributary of the Lumwana East River upstream of the Malundwe copper deposit.
Lum/SW-05	373183	8645623	Chimiwungo Stream, a tributary of the Lumwana East River upstream of the Malundwe copper deposit.
Lum/SW-06	371725	8645541	Small stream, a tributary of the Lumwana East River to the south of the Malundwe copper deposit.
Lum/SW-07	369212	8647476	Malundwe Stream, upstream of the confluence with the Lumwana East River.
Lum/SW-08	371517	8646423	Bridge crossing over minor stream South East of the Malundwe Copper Clearing.
Lum/SW-09	370950	8646950	Small tributary of the Lumwana East River. The confluence with the ELR is 50 m downstream of Lum/SW-02. The monitoring site is 100m upstream of the confluence.

Sampling Procedures

Sampling was carried out in accordance with international procedures for the collection of surface water samples for physical, chemical, bacteriological and metal analyses. The surface water sampling, storage and transportation protocol is described in Appendix J.

Sample Analysis

Sample analysis was conducted at the A. H Knight analytical laboratory in Kalulushi, Zambia. The laboratory is ISO 9002 accredited.

3.7.7 Surface Water Quality

Review of Baseline Water Quality

The results of surface water analyses and field water quality measurements are presented in Appendix K.

Lumwana East River

Surface water monitoring site Lum/SW-01

Based on the analysis many metal concentrations were below the level of detection at Lum/SW-01 from November 2001 to October 2002. Those exceptions are as follows:

- The mean concentration of aluminium at Lum/SW-01 was 0.4 mg/L, with the highest value of 0.8 mg/L recorded in February 2002;
- Detectable lead concentrations were recorded as 0.34 mg/L in November 2001 and 0.1, 0.2 and 0.3 mg/L in August, September and October 2002 respectively;
- Uranium concentrations were below the detection limit for most of the year but values of 0.4 mg/L were recorded in November 2001 and June 2002;
- Selenium concentrations were below the detection limit with the exception of 0.02 mg/L recorded in May 2002;
- Cobalt concentrations were below the detection limit except in October 2002 when a value of 0.8mg/L was recorded;
- Neutral pH values were generally recorded between November 2001 and October 2002 apart from pH 5.3 in January 2002 and pH 6.3 in April 2002;
- Mean conductivity was 59 μS/cm with a peak value of 130μS/cm recorded in November 2001 and a low value of 33 μS/cm recorded in February and May 2002. Conductivity inversely correlated with flow rate i.e. conductivity increased as the flow rate decreased;
- Mean TDS, TSS and sulphate values were 30, 13 and 14 mg/L respectively. TDS correlated closely with conductivity; and
- The faecal coliform count decreased from 464/100mL to 0/100mL from November 2001 to October 2002. The mean faecal coliform count at Lum/SW-01 was 88.5/100mL.

Surface water monitoring site Lum/SW-02

At Lum/SW-02 from November 2001 to October 2002, analysis was similar to SW-01 in terms of many metal concentrations being below detectable limits. Exceptions to this are discussed below.

In summary:

- The mean concentration of aluminium at Lum/SW-02 was 0.23 mg/L with the highest value of 0.30 mg/L recorded in February 2002;
- Detectable lead concentrations of 0.1, 0.2 and 0.3 mg/L were recorded in August, September and October 2002 respectively;
- Uranium concentrations were generally below the detection limit with the exception of concentrations of 0.2, 0.2 and 0.4 mg/L recorded in November 2001, and May and June 2002 respectively;
- A selenium concentration of 0.02 mg/L was recorded in May 2002 but otherwise selenium was below the detection limit;
- Relatively neutral pH values were recorded between November 2001 and October 2002;
- Mean conductivity was 61 μS/cm with a peak value of 168 μS/cm recorded in October 2002 and a low value of 30 μS/cm recorded in June 2002. Conductivity inversely correlated with flow rate i.e. conductivity increased as the flow rate decreased;
- Mean TDS, TSS and sulphate values were 30 mg/L, 12 mg/L and 13 mg/L respectively with TDS correlating closely with conductivity; and
- The faecal coliform count decreased from 208/100 mL to 0/100 mL from November 2001 to October 2002. The mean faecal coliform count at Lum/SW-02 was 88.5/100 mL.

Surface water monitoring site Lum/SW-03

Similar water quality was recorded at SW-03, noted exceptions are

- The mean concentration of aluminium at Lum/SW-03 was 0.33 mg/L with the highest value of 0.70 mg/L recorded in August 2002;

- Detectable lead concentrations of 0.1, 0.2 and 0.1 mg/L were recorded in August, September and October 2002 respectively;
- Uranium concentrations were generally below the detection limit throughout the year but values of 0.4 and 0.1 mg/L were recorded in November 2001 and May 2002 respectively;
- Relatively neutral pH values were recorded between November 2001 and October 2002
- Mean conductivity was 67 μS/cm with a peak value of 179 μS/cm recorded in October 2002 and a low value of 11 μS/cm recorded in November 2001. Conductivity inversely correlated with flow rate i.e. conductivity increased as the flow rate decreased;
- Mean TDS, TSS and sulphate values were 40 mg/L, 14 mg/L and 9 mg/L respectively with TDS correlating closely with conductivity; and
- The faecal coliform count decreased from 360/100 mL to 0/100 mL from November 2001 to February 2002 and remained at 0/100 mL thereafter. The mean faecal coliform count at Lum/SW-03 was 90/100 mL.

Conclusion

Although some seasonal variations are evident, the water quality in the Lumwana East River is similar along its course with little discernible difference between locations upstream of the Malundwe deposit (Lum/SW-01) and locations downstream of the deposit (Lum/SW-02 and Lum/SW-03). Faecal coliform concentrations decreased from November 2001 (start of wet season) to October 2002 (end of the dry season). Relatively high faecal coliform values recorded in the month of November are likely to be the result of initial rains washing dry season coliform accumulations into watercourses. As expected, conductivity values increased as river flow rates decreased and dissolved elements become more concentrated. Detectable concentrations of lead were recorded in August, September and October 2002. This is attributed to groundwater recharge from the mineralised formations.

In general the quality of water in the Lumwana East River is good. However, faecal coliform (during the wet season) and aluminium, lead and selenium occasionally exceed the Zambian Drinking Water Standards as indicated in Table 3-9.

Surface water quality in the streams and rivers (Lum/SW-04 to Lum/SW-09) of the project area are very similar with the exception of monitoring site SW-09. All sampling locations have neutral pH, similar conductivity values and similar TDS, TSS, sulphate, aluminium, iron, lead and uranium concentrations. Mean element concentrations in the smaller Lumwana South and Kababisa Streams are slightly higher because of lower flow rates.

Sampling site SW-09 has relatively high conductivity and elevated sulphate and TDS concentrations. This is attributed to groundwater issuing from exploration drill holes in the Malundwe deposit and draining into the streams.

Table 3-9: Lumwana River - Parameters Exceeding Zambian Drinking Water Standards

Parameter	Zambian Drinking Water Standards	Maximum Parameter Values Nov 2001 to Oct 2002		
		Lum/SW-01	Lum/SW-02	Lum/SW-03
Faecal Coliform	0/100 mL (Nil)	464/100 mL	208/100 mL	360/100 mL
Total Aluminium	0.05 - 0.2 mg/L	0.80 mg/L	0.30 mg/L	0.70 mg/L
Total Lead	0.05 mg/L	0.34 mg/L	0.30 mg/L	0.20 mg/L
Total Selenium	0.01 mg/L	0.02 mg/L	0.02 mg/L	-

Baseline water monitoring data indicates surface water in the project area to be generally of good quality. However, aluminium, selenium, lead, uranium and cadmium concentrations occasionally exceed Zambian Drinking Water Quality Standards at most monitoring sites. Bacterial faecal coliform counts recorded at all monitoring sites between November 2001 and May 2002 also exceeded Zambian Drinking Water Quality Standards. The presence of coliform in surface water is a cause for concern because informal settlements in the area use the watercourses as a source of drinking water. Faecal coliform is associated with the incidence of medical illnesses such as gastroenteritis, typhoid and cholera.

Total coliform and faecal coliform counts at all monitoring sites decreased from the start of the wet season (November 2001) to the end of the dry season (October 2002). This trend is explained by surface runoff. During the dry season faecal coliform (from animal and bird droppings, etc) accumulates on the ground. At the start of the rains the coliform is washed into the streams and rivers. Gradually the ground is 'washed" of coliform and less coliform is transported into the streams and rivers resulting in a progressive decrease in faecal coliform concentrations. In the dry season when surface runoff is zero, faecal coliform is no longer washed into watercourses and builds up again on the ground surface until the next rains.

Baseline surface water quality results for parameters with detectable values are summarised in Table 3-10.

Table 3-10: Baseline Surface Water Quality - Mean Values, Nov 2001 to October 2002

Sampling Site	Parameter								
	pH range	EC μS/cm	TDS mg/L	SO_4 mg/L	F.C./ 100 mL	Al Mg/L	Fe mg/L	Pb mg/L	U mg/L
Lum/SW-01	5.3 - 7.7	59	37	14	122	0.40	0.40	0.07	0.08
Lum/SW-02	6.6 - 7.4	61	30	13	89	0.23	0.45	0.06	0.07
Lum/SW-03	6.6 - 7.4	67	40	9	90	0.33	0.35	0.04	0.04
Lum/SW-04	6.3 - 7.3	74	51	22	38	0.30	0.18	0.04	0.13
Lum/SW-05	6.4 - 7.3	34	22	10	54	0.80	0.43	0.01	0.12
Lum/SW-06	6.2 - 7.3	56	37	15	45	0.30	0.33	0.01	0.08
Lum/SW-07	6.7 - 7.4	54	38	13	20	0.23	0.33	0.03	0.13

Comparison with previous monitoring data

The SRK Environmental Baseline Report, 1996 indicated that surface water quality in the project area was very good. At that time the water quality was in compliance with the South African water quality standards for potable and agricultural use. The current baseline monitoring indicates that water quality is similar with TDS values deviating only slightly from the SRK mean results. However, SRK did not analyze for total coliform and faecal coliform and currently water quality data does not meet World Health or Zambian Drinking Water quality Standards, due to the presence of coliform. Total coliform and faecal coliform were found to be 3200/100mL and 464/100mL respectively at monitoring site Lum/SW-01 in November 2001. Mean faecal coliform values of 65.4/100mL were recorded over the study area from November 2001 to October 2002.

The SRK report indicated that water quality in the Lumwana East River deteriorated after contact with the Malundwe copper deposit. Current baseline water quality data shows that there is little discernible difference in surface water conductivity upstream (Lum/SW-01) and downstream (Lum/SW-02) of the deposit. Conductivity measurements and sulphate concentrations in the monitoring area are lower now than in 1996. The variation in results may be attributed to differing sample storage conditions, sample transit time and the use of a South African laboratory.

SRK reported upstream conductivity and sulphate concentration at monitoring site SRK 1 (Lum/SW-01) as 97 μS/cm and 16 mg/L respectively. Downstream conductivity and sulphate at site SRK 4 (Lum/SW-02) was 254 μS/cm and 50.6 mg/L respectively.

Table 3-11 shows the mean conductivity values in the Lumwana East River, upstream and downstream of the Malundwe deposit from November 2001 to October 2002.

Table 3-12 compares mean conductivity, and mean iron and TDS concentrations for all SRK (1994-96) and AMC (November 2001 to October 2002) monitoring sites. There is no significant variation above and below the Malundwe Deposit.

Table 3-11: Mean Conductivity Values for the Lumwana River, Nov 2001 to Oct 2002

Monitoring Sites Lum/SW-01, SW-02, SW-03, SW-04, SW-05, SW-06 & SW-07	Mean Conductivity (µS/cm)
All monitoring sites upstream of Malundwe deposit	55.7
All monitoring sites downstream of Malundwe deposit	64.0

Table 3-12: Mean EC, Fe and TDS Values - SRK 1994-96 and AMC Nov 2001-Oct 2002

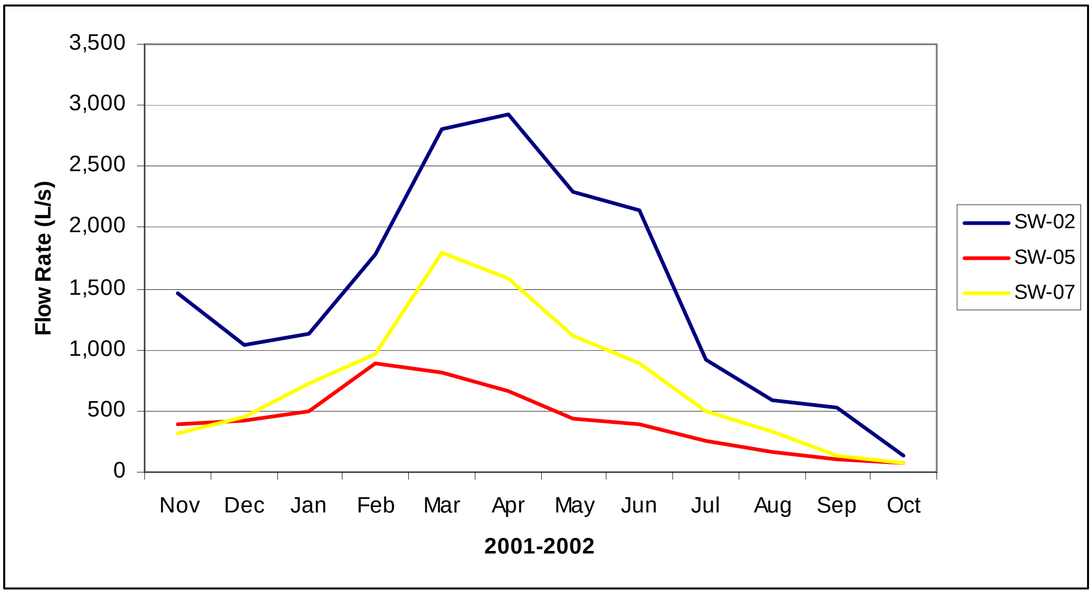
Parameter	Mean Values SRK (1994-96)	Mean Values AMC (Nov 2001 to Oct 2002)
Conductivity (µS/cm)	69	57.8
Fe (mg/L)	0.41	0.35
TDS (mg/L)	44	37.7

3.7.8 River & Stream Flow Rate Measurement

Flow rate measurement is required for mine design, monitoring and quantification of project impacts, and to characterise site surface hydrology. Monthly monitoring was adopted at Lumwana due to the remoteness of the site and the long distances between monitoring sites. Flow rate measurement was performed at monitoring sites Lum/SW-02, Lum/SW-03, Lum/SW-04, Lum/SW-05, Lum/SW-06 and Lum/SW-07. The dilution gauging method of flow measurement was used at all sites except Lum/SW-03 where the float method was used. River and stream flow rate measurement results are presented in Table 3-13.

The data indicates the time lag between peak monthly rainfall and peak monthly flow to be approximately one month in the smaller streams and up to 3 months in the Lumwana East River (monitoring sites Lum/SW-02 & Lum/SW-03). This time lag is illustrated graphically in Figure 3-7. The graph shows that peak discharge on the Chimiwungo Stream at Lum/SW-05 occurred in February and peak discharge on the Lumwana East River at Lum/SW-02 occurred in April. The 2 - 3 month time lag on the Lumwana East River is attributed to the river's large catchment area and the capacity of large dambos and wetlands to retain water. However, field observations indicate the lag time following individual rainfall events to be much less with river levels rising and falling rapidly within a matter of hours depending on the duration of the rainfall.

Figure 3-7: Flow Rate Data for Lum/SW-02 (Lumwana East River), Lum/SW-05 (Chimiwungo Stream) and Lum/SW-07 (Malundwe Stream)



The 1-year baseline rainfall and stream flow rate data for the Lumwana site, backed up with 30-year rainfall data records from Solwezi and Mwinilunga meteorological stations, was used for mine design.

Electrical conductivity measurements described in Section 3.7.7 indicate an increase in conductivity as stream flow rates decrease during the dry season. This suggests that much of the dry season base flow is made up of groundwater.

The Lumwana stream flow rate data compares favourably with SRK (1994) data for coincident monitoring sites Lum/SW-03, Lum/SW-05 and Lum/SW-07.

Table 3-13: River and Stream Flow Rate Measurements - Nov 2001 to Oct 2002

Monitoring Site	Monthly Flow Rate L/s					
	Lum/ SW-02	Lum/ SW-03	Lum/ SW-04	Lum/ SW-05	Lum/ SW-06	Lum/ SW-07
Nov-01	1,459	-	100	393	9.6	316
Dec-01	1,040	-	53	423	11.5	449
Jan-02	1,134	11,430	115	501	14.1	728
Feb-02	1,778	In flood	394	886	14.6	959
Mar-02	2,800	In flood	320	820	14.3	1,800
Apr-02	2,920	In flood	154	670	13.5	1,590
May-02	2,293	8,200	152	436	12	1,117
Jun-02	2,147	3,150	73	388	9.5	886
Jul-02	914	2,560	66	264	5	504
Aug-02	592	2,700	69	164	3.3	336
Sep-02	522	1,950	66	106	1.7	131
Oct-02	137	1,860	66	82	1.5	68

Estimated daily stream loadings calculated from element concentrations in surface water and stream flow rate measurements are given in Appendix L.

3.7.9 Stream Sediment Survey

A programme of stream sediment sampling and analysis was performed as part of the baseline study. Sediment samples were collected at the surface water monitoring sites Lum/SW-01 to Lum/SW-07 (sampling locations shown in Figure 3.6).Sampling was undertaken in accordance with internationally accepted procedures for the collection of stream sediment samples. The stream sediment sampling protocol is described in Appendix J.

Stream sediment samples were submitted to A.H. Knight Analytical Services for geochemical analysis of sediment solids and dissolved metal analysis on sediment pore water.

The results of the geochemical (sediment solids) and the dissolved metals (pore water) analyses are presented in Appendix M. Sediment geochemical results of significance are summarised in Table 3-14.

Relatively high concentrations of aluminium, boron, iron and uranium were recorded in most of the stream sediments in the project area. Results from SED-04 showed a lower concentration of aluminium and boron compared to other monitoring sites. This is attributed to the dambo watercourse. Sediment at SED-04 showed a higher calcium value than other monitoring sites except SED-07, which showed a very high calcium value of 17,100 mg/kg. This anomalous value cannot be explained at present. SED-01 showed a relatively high copper concentration of 840 mg/kg. All sediment monitoring sites had unexpectedly high uranium concentrations. Uranium concentrations in stream sediment from monitoring sites SED-03 and SED-05 are 500 times higher than the average uranium crustal abundance of 2.7 mg/kg and 1000 times higher than average concentration in soils (Levinson 1974).

Table 3-14: Stream Sediment Geochemical Analysis - Results of Significance

Monitoring Site	Sediment Geochemical Analyses - Element Concentration in mg/kg							
	Al	B	Ba	Ca	Cu	Fe	Mn	U
SED-01	3530	1740	<1	<1	840	6820	41	140
SED-02	2630	1450	<1	<1	18	820	16	130
SED-03	1020	1310	330	<1	<1	<1	<1	1120
SED-04	360	<5	180	230	18	610	10	18
SED-05	2800	1260	<1	<1	<1	4800	42	1490
SED-06	2100	1140	<1	<1	<1	1640	13	690
SED-07	3090	1050	<1	17100	<1	2040	22	330

Analysis of sediment pore water showed dissolved metal concentrations to be generally close to or below detection limits. TDS concentrations varied between 70 and 210 mg/L for all monitoring sites.

During periods of low flow, sedimentation occurs along many stretches of the streams and rivers in the project area. It is assumed that these sediments are re-mobilised and largely transported out of the project area in the wet season. Sediments sampled at the end of the dry season in November 2001 were of silt and fine sand size. Field observations in February 2002 showed much of the sediment had been eroded away and only coarse cobbles remained.

3.8 Aquatic Flora and Fauna

3.8.1 Introduction

The baseline aquatic flora and fauna survey of the project area was undertaken by environmental consultant Mr. Henry Kabunda, Senior Fish Culturist at the National Aquaculture Research and Development Centre, Ministry of Agriculture, Forestry and Fisheries (MAFF), Kitwe, Zambia. The field component of the study was conducted between 14 and 18 of January 2002.

The main watercourses crossing the project area are the Lumwana East River and its tributaries the Chimiwungo and Malundwe Streams. Six monitoring sites were chosen to characterise the aquatic environment. These sites are listed in Table 3-15 and are shown on Figures 3-8 and 3-9.

The collection of site aquatic data focused on the following variables:

- Fish species present in the rivers and streams;
- Stream conditions;
- Fishing activities including information on:
  - Fishing equipment;
  - Frequency of fishing;
  - Fish markets; and
  - Fish consumption;
- Aquatic and Riverine vegetation;
- Aquatic animals; and
- Ornithology.

Figure 3-8: Malundwe Terrestrial and Aquatic Monitoring Sites

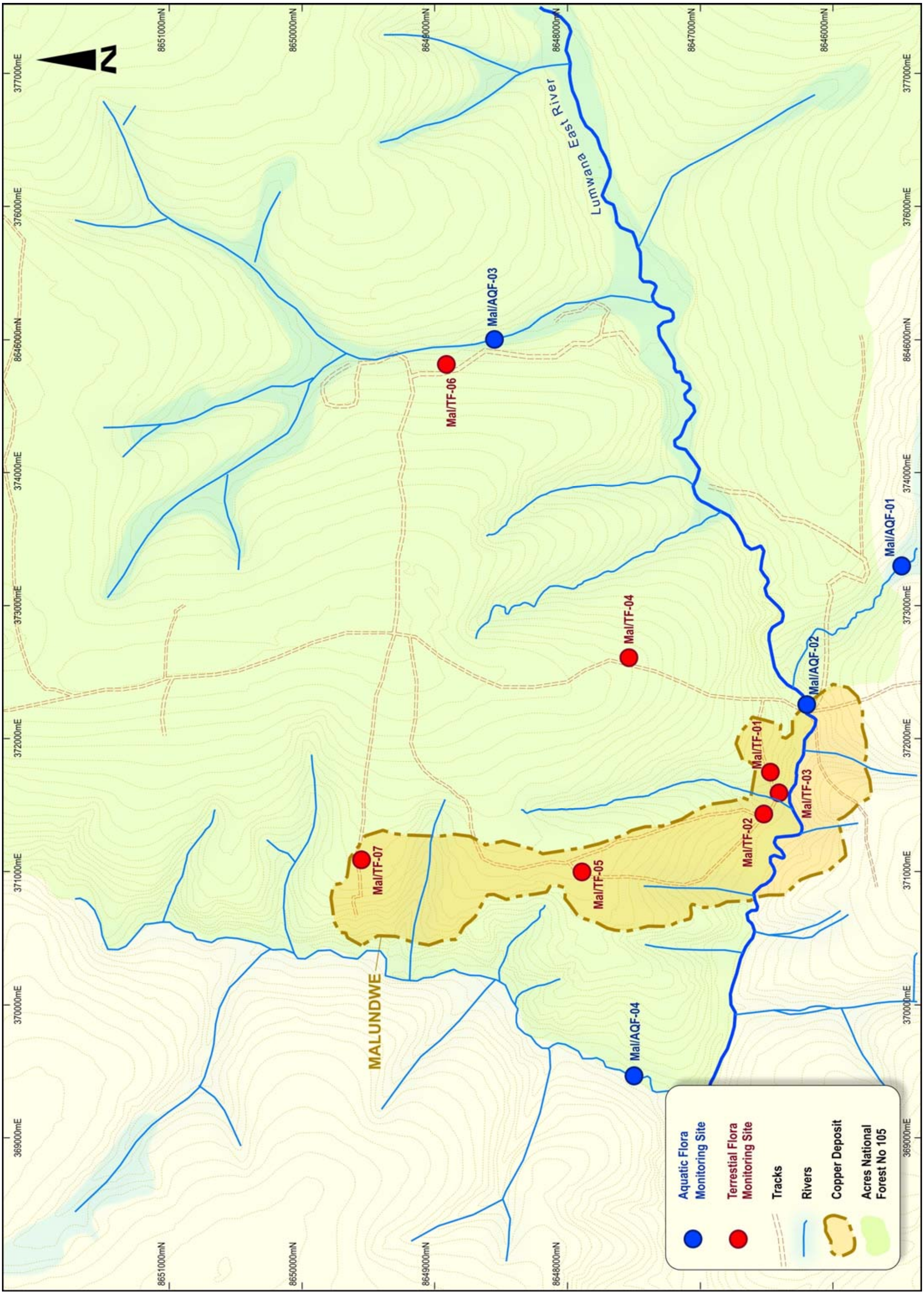
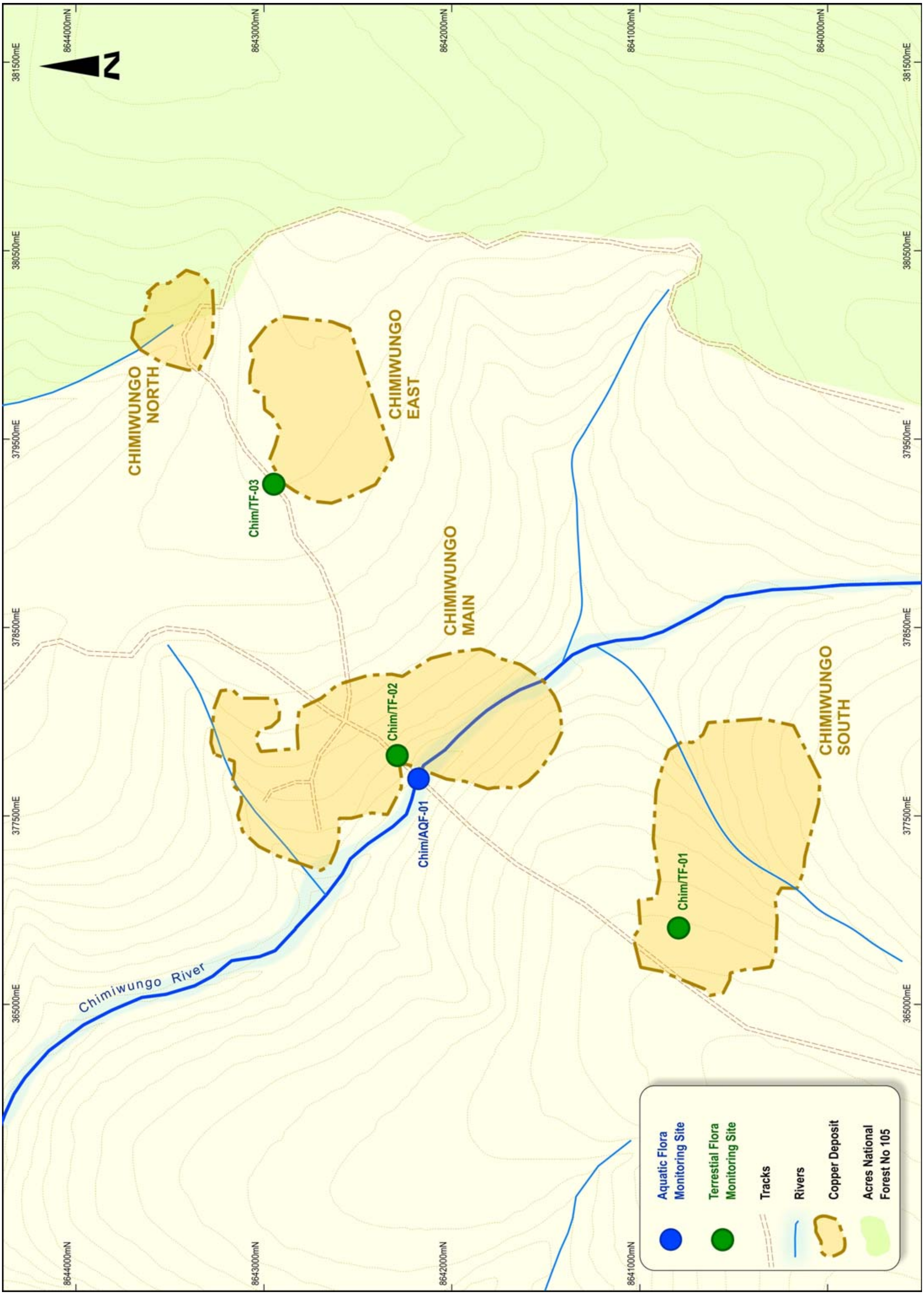


Figure 3-9: Chimiwungo Terrestrial and Aquatic Monitoring Sites



In addition, the United States Environmental Protection Agency (USEPA) protocol for the rapid bio-assessment of streams and wadeable rivers was used to assess the aquatic environment at all six monitoring sites. This approach provided a comprehensive description of the aquatic conditions and riverine / aquatic flora and fauna found on the project site.

Table 3-15: Baseline Aquatic Flora and Fauna Monitoring Sites

Aquatic Site No.	UTM Coordinates	Location Description
Malundwe Site		
Mal/AQF-01	373183E, 8645623N	Masanga Bridge on Chimiwungo Stream
Mal/AQF-02	372235E, 8646296N	Lumwana East River (drill site bridge)
Mal/AQF-03	375047E, 8648662N	Kababisa Stream
Mal/AQF-04	369212E, 8647264N	Malundwe Stream
Chimiwungo Site		
Chim/AQF-/01	377700E, 8642182N	Chimiwungo Stream at Chimiwungo dambo
Mwinilunga Rd.		
Lum/AQF-01	384958E, 8643150N	Mwinilunga Bridge on Lumwana East River

3.8.2 Methodology

The following methods were used to collect data on the aquatic flora and fauna of the area:

(a) *Fish trapping*

Wickerwork basket traps were used at aquatic monitoring sites Mal/AQF-01 (Chimiwungo Stream), Mal/AQF-02 (Lumwana East River) and Mal/AQF-04 (Malundwe Stream). Soil containing termites was used as bait. Molluscs (clams) and crustaceans (fresh water crabs) were also collected during the fish trapping exercise. Samples of fish, molluscs and crustaceans caught were kept on ice and later submitted to A H Knight analytical services for tissue metal analysis.

(b) *Interviews with local inhabitants*

Interviews were conducted on site with local inhabitants who regularly fish the streams and rivers in the project area. Ten individuals were interviewed during the survey. The interviewees were asked simple questions on the aquatic fauna found in and on the banks of the streams. Fish species were identified from pictures and drawings provided by Mr. Kabunda.

(c) *Riverine and aquatic flora survey*

Most of the riverine and aquatic flora was identified at site but plants not immediately identifiable were catalogued, pressed and taken back to Kitwe for later identification.

3.8.3 Survey Results

The results of the fish trapping exercise conducted at four of the aquatic monitoring sites, interviews with local inhabitants and the riverine / aquatic flora survey are as follows:

Fish Species

The fish species found in the Lumwana East River, and Chimiwungo and Malundwe Streams are listed in Table 3-16, and the common scientific and family names of the fish species are given in Table 3-17.

The fish species found in the rivers and streams are present in good numbers. However, in terms of fish abundance, the following fish species are prevalent in the Lumwana aquatic ecosystem:

- *Alestes lateralis* - prefers and shoals in clear slow flowing or quiet well-vegetated waters. Feeds on small aquatic and terrestrial organisms. Moves upstream during wet season to breed;
- *Clarias ngamensis* - Favours vegetated habitats in swamps and riverine flood plains. Eats molluscs, terrestrial and aquatic insects, shrimps, crabs and other fish. Breeds during the wet season in shallow flood drainage channels;
- *Gnathonemus macropidotis* - Widely distributed and commercially important fish species in Zambia. Favours well vegetated, muddy bottomed marginal habitats of rivers and flood plains. It is a shoaling species moving inshore after dark. Feeds on midgets, may fly larvae and pupae taken from the stream bottom and off plant stems; and
- *Mastacembalus mellandi* - Lives in vegetation along the margins of flowing rivers. Also found in rocky crevices. Feeds on insects, shrimps and small fish. Breeds during late dry season and wet season.

Stream Conditions

Stream conditions in the Lumwana East River, and Chimiwungo and Malundwe Streams are described in Table 3-18.

Table 3-16: Fish Species in the Lumwana River, Chimiwungo and Malundwe Streams

No.	Fish Species	Aquatic Monitoring Sites			
		Mal/AQF -01	Mal/AQF -02	Chim/AQF -01	Lum/AQF -01
1.	*Gnathonemus macropidotis*	Present	Abundant	Present	Present
2.	*Alestes lateralis*	Present	Present	Absent	Present
3.	*Auchenoglanis ngamensis*	Present	Present	Absent	Present
4.	*Barbus multilineatus*	Present	Present	Present	Present
5.	*Clarias ngamensis*	Present	Abundant	Present	Present
6.	*Haplochromis philander*	Present	Present	Present	Present
7.	*Marcusenius castelnaui*	Present	Present	Present	Present
8.	*Mastacembalus mellandi*	Present	Present	Abundant	Present
9.	*Schilbe mystus*	Present	Present	Present	Present
10.	*Synodontis nigromaculatus*	Present	Present	Abundant	Present
11.	*Nannocharax multifaciatus*	Present	Present	Present	Present

Table 3-17: Common Scientific and Family Names of Fish Species Found in the Project Area

Common Name	Scientific Name	Family Name
Bull Dog	*Gnathonemus macropidotis*	*Mormyridae*
Strip Tail Robber	*Alestes lateralis*	*Characidae*
Grunter	*Auchenoglanis ngamensis*	*Bagridae*
Many Striped Barbel	*Barbus multilineatus*	*Cyprinidae*
Blunt Toothed Barbel	*Clarias ngamensis*	*Claridae*
Dwarf Bream	*Haplochromis philander*	*Cichlidae*
Stone Basher	*Marcusenius castelnaui*	*Mormyridae*
Spiny Eel	*Mastacembalus mellandi*	*Mastacembelidae*
Silver Barbel	*Schilbe mystus*	*Schitbeidae*
Spotted Squeaker	*Synodontis nigromaculatus*	*Mochokidae*
Many Banded Citharinid	*Nannocharax multifaciatus*	*Citharinidae*

Table 3-18 Lumwana East River and Chimiwungo and Malundwe Stream Conditions

Stream Conditions	Aquatic Monitoring Sites			
	Mal/AQF-01	Mal/AQF-02	Chim/AQF-01	Lum/AQF-01
Stream Bank	Steep hill	Riverine forest	Dambo	Riverine forest
Accessibility	By vehicle	By vehicle	By vehicle	By vehicle
Stream Width*	3 meters	9.5 meters	3 meters	16.5 meters
Stream Depth*	1 meter	1 meter	0.5 meters	1.5 meters
Water Clarity	Tainted green	Tainted green	Clear	Tainted green
Stream Bed	Rocky	Rocky	Sandy	Rocky / sandy
Stream Velocity	Fast / strong	Fast / strong	Fast / strong	Fast / strong

** Approximate measurements.*

Fishing Activities (trapping and netting)

Locally made wickerwork fish traps are used for fishing in the Lumwana East River and Malundwe and Chimiwungo Streams (see Plate 3.1). The fish traps are set to trap fish moving downstream with the current. This type of fish trap does not catch large numbers of fish and therefore does not adversely affect fish stock levels. Fishing is usually practiced in the dry season when the river levels are low.

Plate 3-1:

Aquatic monitoring site Mal/AQF-02 - East Lumwana River.

Example of wickerwork basket used to trap fish in the Lumwana area

The fish trapping exercise carried out as part of the aquatic survey caught two species of fish namely, *Clarias ngamensis* (Blunt Toothed Barbel) and *Haplochromis philander* (dwarf bream). Plate 3.2 is a photograph of the fish caught at monitoring sites Mal/AQF-01 (Chimiwungo Stream), Mal/AQF-02 (Lumwana East River) and Mal/AQF/04 (Malundwe Stream). The size of fish catch and species number reflects the type of trap used and the rising river level.

Nets are seldom used to catch fish. There are no fish markets in the area and most of the fish is consumed fresh. Fish is not caught in large quantities and therefore there is no necessity to preserve it by drying. Due to the sparse population, fishing activity is light.

Information collected on fishing activities in the Lumwana East River, and Chimiwungo and Malundwe Streams is summarised in Table 3-19.

Plate 3-2 *Clarias ngamensis* (Blunt toothed Barbel) and *Haplochromis philander* (Dwarf Bream) caught at the confluence of the Chimiwungo Stream and the Lumwana East River.

Table 3-19: Fishing Activities - Lumwana River, Chimiwungo and Malundwe Streams

Fishing Activities	Aquatic Monitoring Sites			
	Mal/AQF-01	Mal/AQF-02	Chim/AQF-01	Lum/AQF-01
Equipment	Hooks and traps	Hooks and traps	Hooks, traps and poison*	Hooks, traps and poison*
Frequency	Light	Light	Light	Light
Market	Local	Local	Local	Local
Consumption	Fresh	Fresh	Fresh	Fresh / dried

** The poison normally used for fishing is extracted from the shrub species Tephrosia volgeli. Agricultural fertilizer is also used to poison fish.*

Riverine Forest and Aquatic Macrophytes

The low incidence of macrophytes in the aquatic survey is attributed to the strong water currents, which prevent aquatic plants from taking hold. Aquatic plant growth is more common in the slow moving waters found along sections of the Chimiwungo Stream and other small tributaries of the Lumwana East River.

Several fish species feed on aquatic macrophytes, which play an important role in the health of the aquatic ecosystem. The vegetation provides a food source for the fish and also influences the chemical and physical nature of the aquatic environment. Excessive aquatic macrophytes can result in low productivity in the food chain.
The riverine forest and aquatic plant species identified on the banks of the Lumwana East River, and Chimiwungo and Malundwe Streams are listed in Table 3-20.

Aquatic Animals and Birds

Aquatic animals and birds found along the banks of the Lumwana East River, and Chimiwungo and Malundwe Streams are listed in Table 3-21. Aquatic animals and birds are numerous and indicate a healthy aquatic ecosystem.

The USEPA rapid bio-assessment protocol was used to assess the aquatic environment at each of the six aquatic flora and fauna monitoring sites. The competed field data collection sheets are presented in Appendix N. The results of the bio-assessment exercise are summarised in Table 3-22.

Table 3-20: Riverine Forest and Aquatic Plant Species Found in and on the Banks of the Lumwana East River and Chimiwungo and Malundwe Streams

Plant Species	Aquatic Monitoring Sites			
	Mal/AQF-1	Mal/AQF-2	Chim/AQF-1	Lum/AQF-01
Riverine Forest				
Acacia polycantha	Absent	Absent	Absent	Present
Bridelia micrantha	Absent	Present	Absent	Absent
Chrysophyllum magalismonthanum	Absent	Present	Absent	Absent
Dissotis falcipila (shrub)	Absent	Present	Present	Absent
Dissotis princeps	Absent	Absent	Present	Absent
Erythrina abyssinica	Absent	Present	Absent	Absent
Jasminum steptopus	Absent	Present	Absent	Absent
Psychotria succulenta	Absent	Present	Absent	Absent
Rhus longipes	Absent	Present	Absent	Absent
Rothmannia whitfieldi	Absent	Present	Absent	Absent
Similax kraussina (climber)	Absent	Present	Absent	Absent
Syzygium cordatum	Absent	Present	Absent	Absent
Aquatic Plants				
Nymphaea lotus	Absent	Present	Present	Absent
Nymphaea coerulea	Absent	Absent	Present	Absent
Ceratophylum demersum	Present	Absent	Present	Absent
Phragmites mauritania	Absent	Absent	Present	Present
Cyperus papyrus	Absent	Absent	Present	Present

Bio-Analysis of Fish Tissue and Crustaceans

Fish and crustacean samples were collected for bio-analysis between the 8th and 17th February 2002 using wickerwork fish traps. The traps were placed at the confluence of the Malundwe Stream and Lumwana East River, and in the Chimiwungo Stream (Lum/SW-05). The fish and crab species collected, were identified, placed in zip-lock bags and transferred to a cool box with ice. The samples were then placed in a freezer at the ECV Field Camp awaiting transfer in a cool box to A.H. Knight's Analytical Laboratory in Kalulushi.

The USEPA rapid bio-assessment of streams and rivers in the project area indicates an optimal or optimal/sub-optimal habitat for aquatic flora and fauna.

The fish gill tissue was analysed for the heavy metals aluminium, arsenic, cadmium, chromium, cobalt, copper, iron, mercury, nickel, lead, selenium, uranium and zinc, using total acid extraction. The fish and crab tissue was also analysed. Table 3-23 describes the location where the species were trapped and methodologies and findings.

Malundwe stream (MS), and the Chimiwungo Stream. However, the metal concentrations found in different species did differ. The Dwarf Bream had the highest concentration of almost all metals tested, possibly due its smaller body mass, and differences in habitat and food sources. As expected, higher metal concentrations were found in the gills of the fish than in the body tissue.

Water in the Lumwana East River catchment area is of good quality with regards to total metals. However, it is difficult to extrapolate a correlation between water quality and metal concentrations in fish species because metal concentrations in fish are the result of complex interactions between the environment and living organisms.

No fish deformities were observed. It is therefore deduced that the fish in the Lumwana catchment are healthy and that metal concentrations occurring in them are not at high enough levels to be toxic.

Table 3-21: Aquatic Animals and Birds Found in and along the Banks of the Lumwana East River and Chimiwungo and Malundwe Streams

Aquatic Animals and Birds	Aquatic Monitoring Sites			
	Mal/ AQF-01	Mal/ AQF-02	Chim/ AQF-01	Lum/ AQF-01
Aquatic Animals				
Crocodilius niloticus (Nile Crocodile)	Absent	Absent	Absent	Present*
Rana sp. (common frog)	Present	Present	Present	Present
Chloroohis hoplogaster (Green Water Snake)	Present	Present	Present	Present
Hippopotamus amphibius (Hippopotamus)*	Absent	Absent	Absent	Present*
Agama sp. (common lizard)	Present	Present	Present	Present
Dendraspis angusticeps (Black Mamba Snake)	Present	Present	Present	Present
Python sebae (Python Snake)	Present	Present	Present	Present
Arachnic sp. (Red Scorpion)	Present	Present	Present	Present
Rattus sp. / Rattus Rattus (Common Grey Rat)	Present	Present	Present	Present
Grithidea rhizophorarum (Water Snail)	Present	Present	Present	Present
Kinixys sp. (Land Tortoise)	Present	Present	Present	Present
Varanus nilotica (Monitor Lizard)	Present	Present	Present	Present
Raftia pachyptila (Tube Worms)	Present	Present	Present	Present
Aquatic Birds				
Assorted birds (Riverine / Aquatic)	Present	Present	Present	Present
Gypohierax angolensis (Fish Eagle)	Absent	Present	Present	Present
Bycanistes bucinator (Grey Hornbill)	Present	Present	Present	Present

** Found 15 km downstream of the Mwinilunga Road Bridge at the confluence of the East Lumwana and Mwombezhi Rivers.*

Table 3-22: USEPA Rapid Bio-assessment of Aquatic Flora and Fauna Monitoring Sites

Aquatic Site	Location	Habitat Score (Maximum 200)	Aquatic Habitat Description
Mal/AQF-01	Chimiwungo Stream	175	Optimal habitat for aquatic flora and fauna. (Little or no impact from human activity).
Mal/AQF-02	Lumwana East River	162	Optimal habitat for aquatic flora and fauna. (Some impact from human activity).
Mal/AQF-03	Kababisa Stream	152	Borderline optimal / sub-optimal habitat for aquatic flora and fauna (natural quality not conducive to optimal habitat formation and some impact from human sources).
Mal/AQF-04	Malundwe Stream	196	Optimal habitat for aquatic flora and fauna. (Little or no impact from human activity).
Chim/AQF-01	Chimiwungo Stream	182	Optimal habitat for aquatic flora and fauna. (Little or no impact from human activity).
Lum/AQF-01	Lumwana East River	174	Optimal habitat for aquatic flora and fauna. (Some impact from human activity).

The results of bio-analyses on the gills and body tissue of fish and crustaceans caught in the project area indicate a very low concentration of heavy metals. Bio-analyses results are presented in Table 3-24.

Table 3-23: Bio-analysis of Fish and Crab Species Collected from the Project Area

Sample Location	Sample Species	Preservation	Species Quantity	Heavy Metal Analyses
Confluence of Lumwana East River and Malundwe Stream	Dwarf Bream (DB)	Frozen	Two Fish	Al, As, Cd, Cr, Co, Cu, Fe, Hg, Ni, Pb, Se, U, Zn
	Crab (C)	Frozen	Two Crabs	Al, As, Cd, Cr, Co, Cu, Fe, Hg, Ni, Pb, Se, U, Zn
	Spotted Squeaker (SS)	Frozen	Two Fish	Al, As, Cd, Cr, Co, Cu, Fe, Hg, Ni, Pb, Se, U, Zn
	Silver Barbel (SB)	Frozen	Two Fish	Al, As, Cd, Cr, Co, Cu, Fe, Hg, Ni, Pb, Se, U, Zn
	Blunt Toothed Barbel (BTB)	Frozen	Two Fish	Al, As, Cd, Cr, Co, Cu, Fe, Hg, Ni, Pb, Se, U, Zn
Chimiwungo Stream (MAL/AQF-01)	Silver Barbel (SB)	Frozen	Two Fish	Al, As, Cd, Cr, Co, Cu, Fe, Hg, Ni, Pb, Se, U, Zn
	Crab (C)	Frozen	Two Crabs	Al, As, Cd, Cr, Co, Cu, Fe, Hg, Ni, Pb, Se, U, Zn
	Blunt Toothed Barbel (BTB)	Frozen	Two Fish	Al, As, Cd, Cr, Co, Cu, Fe, Hg, Ni, Pb, Se, U, Zn

Table 3-24: Bio-analyses Results on Fish Gills and Body Tissue

Fish Trapping Location	Fish Type	Fish Gills/ Body	Heavy Metals Concentration in Fish Gills and Body Tissue (mg/kg)												
			Al	Cr	As	Hg	Se	Ni	Fe	Cu	Co	Cd	Zn	U	Pb
LER and MS confl.	DB	G	103	32	0.9	BDL	0.5	17	314	17	BDL	1	89	257	34
LER and MS confl	DB	B	44	9	1.3	BDL	0.5	3	92	3	BDL	0.8	28	BDL	BDL
LER and MS confl	C*	C*	24	3	0.3	BDL	0.2	4	70	13	3	0.3	10	13	0.8
LER and MS confl	SS	G	20	8	0.3	BDL	0.4	2	92	1	BDL	0.3	16	29	0.8
LER and MS confl	SS	B	10	3	0.1	BDL	0.1	0.5	28	1	BDL	BDL	8	3	BDL
LER and MS confl	SB	G	37	8	0.2	BDL	BDL	0.4	85	1	0.4	0.4	19	37	BDL
LER and MS confl	SB	B	7	5	0.2	BDL	0.1	0.5	33	1	0.4	BDL	10	7	BDL
LER and MS confl	BTB	G	46	8	0.1	BDL	BDL	2	135	4	BDL	BDL	22	11	BDL
LER and MS confl	BTB	B	39	6	0.2	BDL	BDL	1	63	1	BDL	0.2	11	BDL	5
Site Mal/ AQF-01	SB	G	96	12	0.6	BDL	0.2	4	149	4	BDL	0.5	24	31	7
Site Mal/ AQF-01	SB	B	11	7	0.3	BDL	BDL	2	53	1	0.3	0.1	9	10	2
Site Mal/ AQF-01	C*	C*	30	3	0.1	BDL	BDL	4	91	27	1	0.1	14	4	BDL
Site Mal/ AQF-01	BTB	G	59	10	0.3	BDL	BDL	2	130	2	0.1	BDL	21	22	BDL
Site Mal/ AQF-01	BTB	B	7	4	0.1	BDL	BDL	0.8	28	0.8	BDL	BDL	7	16	0.6

**The two crabs caught at each site were combined to provide one sample*
**BDL: Below Detection Limit*

The metal concentrations found in both the gills and bodies of the fish tested did not differ significantly between those caught at the confluence of the Lumwana East River (LER) and the

The results serve as a good indication of fish health. However, a more definitive conclusion on natural toxic threats to fish cannot be made due to the small size of the survey. The results do however provide useful baseline data for future comparisons.

The highest metal concentrations in fish from the East Lumwana area were iron (314 mg/kg), uranium (257 mg/kg), zinc (89 mg/kg) and aluminium (103 mg/kg). These higher values are attributed to the strong presence of these metals in the soil and stream sediment of the area.

Despite the occurrence of these metals in the tissue of the fish, the low concentration does not pose a toxic threat to fish. The metal levels in the fish gills are significantly lower than that of fish in the Kafue River, which has been adversely affected by pollution from several Copperbelt mines.

Table 3-25 compares the results of tests on the gills of a blunt toothed barbel trapped at the confluence of the Lumwana East River and the Malundwe Stream, and a Nyati pike caught at the Mumbachala Pontoon on the Kafue River approximately 200 kilometres downstream from the Copperbelt (Pettersson, 2002).

Table 3-25: Bio-analyses results on gills taken from a Lumwana Barbel and a Kafue Pike

Fish Type and Location	Heavy Metals Concentration in Fish Gills (mg/kg)							
	Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn
Blunt toothed barbel Lumwana East River	0	0	8	4	135	2	0	22
Nyati Pike* Kafue River	0.146	3.2	1.5	18.3	656	0.776	0	83.4

3.8.4 Conclusions

A general picture of the project area in terms of aquatic bio-diversity can be drawn from the results of the aquatic flora and fauna survey. Fish observations and bio-analyses of fish gills and body tissue indicate that the river and streams in the area conform to the average regional setting and that fish species are relatively healthy and thriving. There is no apparent threat to fish stocks from local fishing activities. The aquatic flora sampled indicates that the watercourses in the summer months (wet season) provide optimal habitats for aquatic flora species. The aquatic floral communities and riverine plant species found on the stream banks suffer little impact from anthropogenic activity and are in very good condition. The area also supports a variety of birds, which from field observations are plentiful.

Overall, the aquatic flora and fauna of the area is very much the norm for the region. The project area is not pristine due to impacts from tree felling, charcoal burners, slash and burn agriculture and mineral exploration activities. Despite these impacts it is concluded, based on the survey findings, that the aquatic environment is within its ‘carrying capacity’ i.e. the impacts to date are not irreversible and the present aquatic environment is sustainable.

3.9 Terrestrial Flora and Fauna

3.9.1 Introduction

The baseline terrestrial flora and fauna study of the project area was undertaken by environmental consultant Mr Lishomwa Mulongwe, Principal Forestry Research Officer at the Forestry Research Department of the Ministry of Environment and Natural Resources in Kitwe, Zambia. Mrs Esnart Chub, scientist responsible for the Forestry Research Department’s Kitwe herbarium assisted Mr Lishomwa. The field component of the study was conducted between 14 and 18 January 2002.

Solwezi district covers an area of 17,600 sq.km and is estimated floristically to have 750 plant species (Fanshawe, 1968). This figure represents about 9 percent of the total number of plant species found in Zambia. The district lies in the North Western Province of Zambia and is covered by Miombo woodland, some relic gallery of *Cryptosepalum* forests, Riparian forests, Munga woodlands, Kalahari woodlands, floodplain and dambo grasslands in various forms, and Chipya or seasonally burnt woodlands.

Some of the common tree genera found in Solwezi district include *Parinari, Marquesia, Brachystegia, Burkea, Syzygium, Isoberlinia and Julbernardia* as canopy dominants, and *Cryptosepalum, Guibourtia, Combretum, Pterocarpus, Ficus, Khaya, Pericopsis* and *Oldfieldia* as sub-canopy dominants. Extensive dambos are also found in the district especially along streams and rivers courses. The dambos are either permanently wet or seasonally inundated plains with grasses of which *Loudetia* and *Hyparrhenia* are typical. Suffrutex flora is a common feature of dry dambos, especially those affected by dry season annual fires.

Solwezi is not one of Zambia's famed wildlife districts, although some game is found in the area. Reedbuck, bushbuck, duiker, hippopotamus, elephant and buffalo were once common mammals of the area. Rare and locally endangered species such as the *Crocidura ansellorum (Ansell's Shrew)* are now restricted to the less accessible parts of the district. Common reptiles include crocodile, python, black mamba, some species of cobra and viper, and water monitors. Large birds of the area include guinea fowl, fish eagles, crows, hawks, hornbills and vultures. The West Lunga National Park, located 70km south west of the project area and the northern corner of the Kafue National Park are the only National Parks in the North Western Province. These parks provide a habitat for species such as elephant, buffalo, lion, leopard, hippopotamus as well as a wide variety of antelope.

A large part of the project area falls within the Acres No.105 National Forest. The national forest gazetted under Government Notice No.67 of 1961 covers an area of 73,000 hectares, 8,100 hectares of which, was degazetted for resettlement purposes on 15 August 1990 under Statutory Instrument No.128 of 1990. The forest was utilised in the past mainly for the extraction of timber and prospecting for minerals, in particular copper and uranium. Major timber concessions were awarded to Mr Cuturi of Chingola from 1960 to 1972, Mindeco from 1973 to 1985, and Apollo through Solwezi Timber Association from 1990 to 1995. The main tree species extracted were *Pterocarpus angolensis, Faurea saligna* and *Isoberlinia angolensis, Brachystegia longifolia and B. spiciformis.* The Malundwe deposit lies within the reserve.

The objectives of the study were twofold. Firstly to determine the number of plant species, their composition and structure and secondly, to determine the species of animals including mammals, birds and reptiles found in the project area.

3.9.2 Methodology

<u>*Vegetation Survey*</u>

The Acres No. 105 National Forest is a large forest reserve and therefore, to make most of the limited time available, a stratified random sampling strategy was adopted to collect information on the flora and fauna in the project area. Each of the four copper deposits (one at Malundwe and three at Chimiwungo) was considered a stratum. Five circular sample plots were sited within the larger Malundwe copper deposit and one circular sample plot was sited within each of the three Chimiwungo copper deposits. Two further sample plot sites were randomly selected in nearby woodlands to form a basis for comparison between copper deposit areas and surrounding woodlands. In addition, four sample plots were randomly located on the Lumwana East River and Chimiwungo Stream to collect samples of Riverine vegetation as part of the aquatic flora and fauna study. Sample plots were coded and the UTM positions determined using a GPS (refer to Figures 3-8 and 3-9, and Table 3-26).

The circular sample plots were sixty metres in diameter covering 0.28 hectares. A small plot of three metres diameter was sited at the centre of each sample plot for the collection and identification of herbaceous plants. The sampling strategy involved the following protocol:

- The number of stems per hectare was used as a measure of stand density;
- Species composition was expressed in terms of frequency of occurrence, the most frequent species indicated as common and the least frequent as rare;

- Determination of growth forms (tree, shrub and herb) and forest structure was done using plant heights and diameters. Diameter at breast height and commercial (part of tree trunk that can be used for timber) heights were taken for all trees found in the sample plot areas; and
- Identification of forest flora followed F White's Forest Flora of Northern Rhodesia, 1962.

Table 3-26: Stand Basal Area and Volume for Malundwe and Chimiwungo Areas

Sample Site	UTM GPS Co-ordinates	Location	Basal Area/ha. (m^2)	Vol./ha. (m^3/ha.)
Malundwe				
Mal/TF-01*	371740E, 8646469N	Copper clearing	2.8	N/a
Mal/TF-02*	371424E, 8646523N	Copper clearing	5.6	N/a
Mal/TF-03	371581E, 8646407N	South area of deposit	21	147
Mal/TF-04	372603E, 8647542N	1.5 km east of deposit	36	181
Mal/TF-05	370985E, 8647892N	Central area of deposit	40	142
Mal/TF-06	374820E, 8648911N	3.75 km east of deposit	16	48
Mal/TF-07	371081E, 8649555N	North area of deposit	65	295
Chimiwungo				
Chim/TF-01	376910E, 8640800N	Southern deposit	31	123
Chim/TF-02	377820E, 8642285N	Central deposit	28	81
Chim/TF-03	379265E, 8642950N	Northern deposit	45	159

**No height measurements were taken for the copper clearings due to the stunted nature of most of the vegetation.*

Wildlife Survey

The type of wildlife, location and frequency of occurrence in the project area was assessed by interviewing local people. The following questions were asked:

- What animals were once present in the area?
- What animals are found in the area today? and
- What in their opinion has caused the changes in animal population structures?

This approach is normally used where the subject of study is not confined to one area or is rarely seen but known to occur in the area.

In addition, the Lusaka branch of the International Union for the Conservation of Nature (IUCN) was contacted to obtain a copy of the threatened species 'Red List' for the North Western Province of Zambia.

3.9.3 Survey Results

Flora Data

The diameter and height data collected was used to plot diameter distributions, and to determine stand basal area and timber volume per hectare for the areas surveyed. The number of species surveyed including their names, and index of frequency of occurrence for each species for all sample areas is listed in Table 3-27.

Diameter Distribution

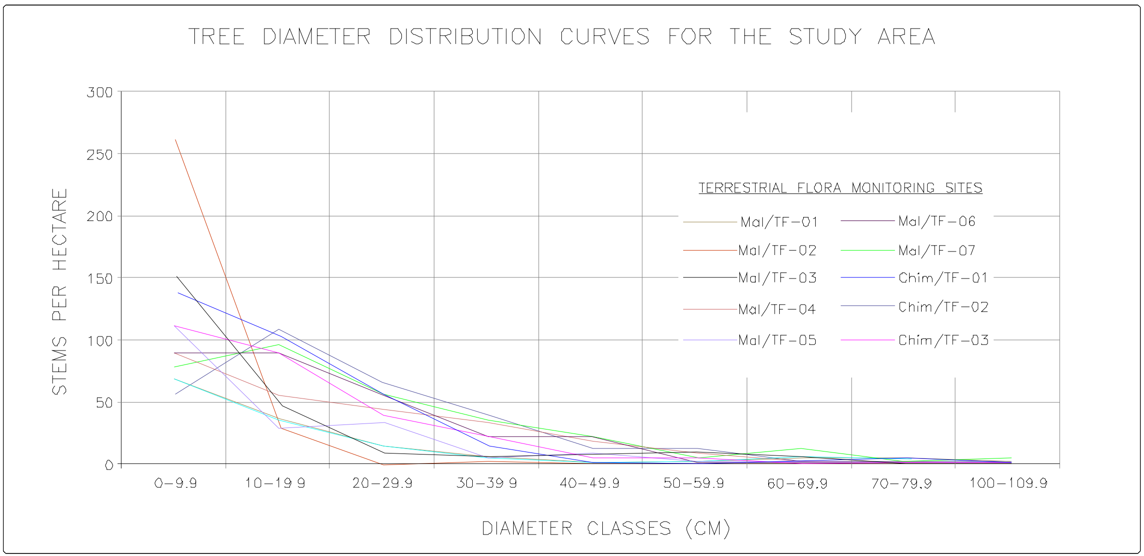
The diameter distribution per hectare is a useful measure of forest growth. The data is usually presented graphically as the number of stems in a given diameter class per hectare. The information is used to determine regeneration potential and forest growth where continuous inventory data is not available (Avery & Burkhart, 1994). The stage of growth of the woody vegetation per hectare at the time of inventory for all the sampled areas is shown in Figure 3-10. The distribution is typical of uneven aged stands.

Table 3-27: Plant Species Surveyed at All Sites and Index of Frequency of Occurrence

No.	Species Latin Name	F.I.	No.	Species Latin Name	F.I.
1	*Abrus precatorius*	LO	56	*Habenaria macroura*	*LF*
2	*Adiantum capillus verieris*	O	57	*Hemizygia bracteosa*	R
3	*Adenodolichos punctatus*	LF	58	*Hymenocardia acida*	LF
4	*Aframomum biaviculatum*	F	59	*Indigofera glaucifolia*	LF
5	*Albizia adianthifolia*	C	60	*Indigofera mimosoides*	LF
6	*Albizia antunesiana*	LF	61	*Isoberlinia angolensis*	C
7	*Aloe spp*	R	62	*Justicia elengatula*	LC
8	*Amblygonocarpus andongensis*	F	63	*Landolphia kirki*	O
	Ancylanthus rogersi		64	*Landophia parvifolia*	O
9	*Anisophyllea boehmii*	LF	65	*Lantana trifolia*	LF
10	*Annona stenophylla*	F	66	*Leptactina benguelensis*	O
11	*Asparagus africanus*	O-LF	67	*Loudetia flavida*	C
12	*Baphia bequaerti*	O	68	*Markhamia obtusifolia*	LF
13	*Becium homblei*	LO	69	*Maprounea africana*	LO
14	*Becium obovatum*	LF	70	*Marquesia macroura*	LF
15	*Brachystegia longifolia*	F-LC	71	*Monanthotaxis schweinfurthii*	O
16	*Brachystegia spiciformis*	LC	72	*Monotes katangensis*	LF
17	*Brachystegia wangermeeana*	C	73	*Monotes africanum*	LF
18	*Bridelia micrantha*	O-F	74	*Ochna pulchra*	LF
19	*Bulbophyllum*	LF	75	*Ochna schweinfurthiana*	O
20	*Bulbostylis mucronata*	LF	76	*Oldfieldia dactylophylla*	LF
21	*Burkea africana*	R	77	*Osmunda regalis*	O
22	*Canthium crassum*	LF	78	*Otiophora scabra*	O-LF
23	*Canthium venosum*	LF	79	*Oxyanthus speciousis*	O
24	*Canthium vulgare*	LO	80	*Parinari curatellifolia*	LF
25	*Chrysophyllum magalismontanum*	LO	81	*Paropsia brazzeana*	O-LF
26	*Cissus petiolata*	O-LF	82	*Pericopsis angolensis*	F-LC
27	*Cleistanthus milleri*		83	*Phragmites mauritianus*	F-LC
28	*Clematis brachiata*	LF	84	*Phyllanthus reticulatus*	F
29	*Clematopsis scabiosifolia*	O-F	85	*Pleiotaxis eximia*	O
30	*Clerodendrum buchneri*	O	86	*Polygonum pulchrum*	LF
31	*Clerodendrum tanganyikense*	O	87	*Phyllocosmus lemaineris*	LF
32	*Clitoria kaessneri*	LF	88	*Protea gaguedis*	O-LF
33	*Combretum molle*	LF	89	*Pseudolachnostylis*	LF
34	*Combretum zeyherii*	C		*maprouneifolia*	
35	*Commelina benghalensis*	F-C	90	*Psychotria sp.*	O
36	*Commelina spp*	F	91	*Psychotria succulenta*	O-LF
37	*Cussonia kirki*	C	92	*Pteridium aquilinum*	C
38	*Cyperus papyrus*	LF	93	*Pterocarpus angolensis*	C
39	*Desmondium repandium*	O	94	*Rhus longipes*	LF
40	*Desmondium spp*	LF	95	*Rhybchosia resinosa*	O
41	*Desmondium salicifolium*	O-LF	96	*Securidaca longipedunculata*	O-LF
42	*Diospyros virgata*	LF	97	*Smilax kraussiana*	F
43	*Diplorhynchus cordylocarpon*	O	98	*Strychnos cocculoides*	LF
44	*Dissotis falcipila*	O	99	*Swartzia madagascariensis*	LF
45	*Erythrina abyssinica*	F-LC	100	*Syzygium cordatum*	F
46	*Erythrophleum africanum*	O	101	*Syzygium guineense*	LF
47	*Eulophia cuculeta*	LF		*sub-species guineense*	
48	*Fadogiella stigmatiloba*	LF	102	*Syzygium guineense*	LF
49	*Fadogia tomentosa*	O		*sub-species macrocarpum*	
50	*Faurea saligna*	O	103	*Triumfetta tomentosa*	O
51	*Ficus spp*	LF	104	*Uapaca kirkiana*	F
52	*Flacourtia indica*	FC	105	*Uapaca nitida*	LF
53	*Garcinia smeathmanni*	LF	106	*Vangueropsis lanciflora*	O-LF
54	*Gardenia imperialis*	LF	107	*Vitex madiensis*	O
55		O	108	*Vitex doniana*	O-LF
56		O-LF	109	*Xylopia odoratissima*	F-LC

Frequency Index (F.I.): LO - Local F - Frequent C - Common R - Rare O – Occasional

Figure 3-10: Stage Growth of Woody Vegetation per Hectare



Species Diversity

Plant species diversity in the area was determined as the total number of species encountered during the survey. One hundred and nine different species were encountered. This figure is based on the number of species collected or recorded.

Basal Area and Volume Production

Stand density is expressed as basal area per hectare for each of the areas sampled. Volume production was determined for all sample areas with the exception of the copper clearings. A breakdown of stand basal area and volume for the Malundwe and Chimiwungo survey sites is given in Table 3-26. The volume figures are based on commercial height and not the total height of individual trees.

Fauna Data (Mammals, Reptiles and Birds)

Although the East Lumwana area is well forested with minimal habitat disturbances in the forest reserve area, the fauna survey exhibited a conspicuous absence of wildlife with the exception of birds which were quite plentiful and evident from the many and continuous bird sounds heard by the survey team. The wildlife present in the project area is listed in Table 3-28. The information is based on field observations and interviews with local people during the course of the survey.

Table 3-28: List of Wildlife Found in the Lumwana Project Area

Mammals	Reptiles	Birds
Bush Baby	Black Mamba	Horn Bills
Bush Buck	Python	Guinea Fowls
Duiker	Viper	Night Jar
Hippopotamus *	Green Water Snake	Sun birds
Vervet Monkey	Tree Frogs	Wild doves
Bats	Lizards (Agama Agama)	Fish Eagle
		Common Birds

**commonly sighted at confluence of East Lumwana and Mwombezhi Rivers 15 km downstream of Mwinilunga Road bridge.*

According to the IUCN Red List there are 120 vulnerable and endangered species in Zambia. The *Crocidura ansellorum* (Ansell's Shrew) is the only species found in North Western Zambia that is on the critical list of threatened species. There are no recorded sightings of Ansell's Shrew in or near the project area.

3.9.4 Discussion of Survey Findings

Vegetation Composition and Structure

The vegetation of the surveyed forest area, although disturbed in places due to agriculture and mineral prospecting activities, is still very typical of Miombo type woodland. According to Chidumayo (1995) the North Western Province of Zambia has a mean plant species diversity of 75 per hectare. This study found 109 species from all the sampled areas, which is relatively high considering the relatively few sample plots. The study also found that stand basal area was higher on all plots with the exception of the copper clearings, a factor attributed to low copper tolerance of most woodland species (Wild, 1969). A short over-storey of *Xylopia odoratissima* and *Combretum molle* dominated the two copper clearings over the Malundwe copper deposit, and a rich ground layer dominated by the geophytes *Becium homblei* (copper flower), *B. obovatum,* and the grass *Loudetia flavida* (see Plate 3.3). The rest of the study area exhibited a much higher average top height of 20 meters or more, and an average basal area of 35.13 m^2 compared to 5.6 m^2 and 2.8 m^2 for the two copper clearings. The species mix especially for the canopy layer was better with the normal Miombo species predominating, while species like *Phyllocosmus lemaineris, Oldfieldia dactylophylla, Burkea africana* and *Marquesia macroura* were more common at Chimiwungo and in the northern part of the Malundwe area.

Plate 3.3 The Southern Copper Clearing at the Malundwe Copper Deposit.

Effect of Disturbances on Vegetation Composition and Structure

The vegetation of the project area appears to be affected by several interacting factors, which are edaphic, climatic and biotic. Past timber concessions, although selective in nature, resulted in many timber species of greater than thirty cm diameter being harvested. A review of the forest records at the Provincial Forestry Office in Solwezi showed that *Pterocarpus angolensis* (Mukwa), *Faurea saligna* (Saninga), *Isolberlinia angolensis* (Mutobo) and *Brachystegia* (Muombo) species were widely harvested in the area from the mid 1960's to the mid 1990's. The diameter distribution curves attest to the fact that most of the trees in the project area are in the regenerative phase, although a few larger ones were observed (see Plate 3.4). Regenerating species include the genera *Pterocarpus angolensis, Ochna pulchra, Isolberlinia angolensis,* and *Faurea salingna.* The observed trend was also influenced by the stunted nature of vegetation on copper clearings, which rarely exceeded twenty centimeters in average diameter. Fire scars on most tree species indicated that seasonal fires pass through the area every year, although the damage appears to be minimal.

Wildlife, Wildlife Habitats and Anthropological Factors

According to the local people interviewed during the survey most of the abundant wildlife that was present in the area over thirty years ago has been decimated by poaching and over hunting. Population pressure is also a contributing factor as the area around the forest reserve is fairly well populated and the Meheba (UNHCR) refugee camp is close to the Acres No.105 National Forest.

Conservation Value

The project area has numerous streams and seepage dambos. Riverine vegetation and common grasses like *Phragmites mauritania* and *Hyparrhenia rufa* are a common feature of the area. In the more mature woodland areas, larger tree species carry a fair amount of epiphytic vegetation. The most common plants include tree ferns, straggler figs, and orchids especially of the genus *Bulbophyllum.* These were not restricted to any particular location but were well distributed throughout the project area.

Conclusions

The vegetation of the Acres No.105 National Forest is typically Miombo, disturbed in places, especially where local people have cultivated the land and timber has been exploited without adequate control. The mineral prospecting companies have over the years contributed to the observed disturbance through the construction of access roads and clearing of drill sites. Generally, the area is well wooded, with a good vegetation cover. The salient terrestrial flora and fauna features of the area are as follows:-

- Most of the tree species are in their regenerative phase, or if growing on copper clearings, severely stunted. These factors contributed to the observed trend in tree diameter distribution;
- The area has a relatively high number of plant species, most of, which are found elsewhere in the Acres No.105 National Forest and countrywide;
- The differences observed in basal areas (refer to Table 3-24) may be due to species assemblages, edaphic factors like copper toxicity and soil moisture levels, aspects which were beyond the scope of this study;
- The study revealed that there is very little wildlife in the area, mainly due to population pressure and over-hunting.

3.10 Cultural Resources

3.10.1 Introduction

Mr. Denis Haambote (archaeologist) and Mr. Jacob Chilufya (geo-morphologist) of the National Heritage Conservation Commission NHCC North-West Region undertook the baseline cultural and natural resources study of the project area. The NHCC is a Statutory Body established under Chapter 173 of the Laws of Zambia. Section 48 and 49 of Chapter 173 entrusts the commission with the responsibility of protecting all ancient heritage and National Monuments from any unauthorised exploitation, excavation or damage. NHCC carried out the field component of the study between 6 and 8 December 2002. A report entitled Heritage Impact Assessment Study Report for Equinox Copper Ventures Limited was subsequently issued in late December 2002.

3.10.2 Study Objectives

The objectives of the study were to:

- Identify and prepare an inventory of cultural and natural heritage resources that occur in the project area;

- Describe and evaluate the cultural and natural resources identified and assess their significance at local, national and international level;
- Assess the likely impacts of project development on heritage resources; and
- Make recommendations for the preservation and/or conservation of these resources in the context of the proposed mining project.

Plate 3.4
Parinari curatelifolia
Largest of the tree species recorded in the Chimiwungo woodland.

3.10.3 Survey Methodology

Due to the limited time available to complete the survey, a surface research strategy was adopted. This entailed sampling potential sites of human habitation such as dambo areas and the margins of streams. Potential areas for investigation were selected using 1:50,000 scale topographic plans and maps showing the morphology of the area and proposed mine developments. Selected sites were thoroughly surveyed on foot for signs of past human habitation or use. This was not easy because of dense undergrowth due to the survey being conducted in the wet season. Due to the limited time period and dense vegetation cover, large portions of the project area especially along the Lumwana East River, which is potentially rich in archaeological finds, could not be surveyed.

3.10.4 Cultural/Archaeological Heritage Survey Results

The cultural survey revealed that Late Stone Age people once occupied the area along the Lumwana East River. However, there is no evidence of any ancient copper workings, which suggests the people that lived in the area at that time were unaware of the Malundwe and Chimiwungo copper deposits.

The survey recorded four cultural/archaeological sites in close proximity on the banks of or close to the Lumwana East River. Their location is shown in Figure 3-11 and the sites are described as follows:

Site 1 - South Bank, Lumwana East River (UTM 373100 E, 8646380 N)

This site is located on the south bank of the Lumwana East River and consists of engravings on a small rock outcrop facing the stream. The engravings consist of 23 pock markings and 6 incised strokes. The condition of the engravings is good, as they have not suffered from any human or natural disturbance. No local traditions are associated with the engravings, although a traditional Kaonde beehive was observed on top of the rock shelter.

Site 2 - South Bank, Lumwana East River (UTM 373100 E, 8646350 N)

This site is located just to the north of Site 1 and consists of 13 pock markings arranged in a circular pattern (see Plate 3.5). The engravings have not been affected by any human disturbance. No surface finds were made and there was no evidence of any local traditions associated with the site.

Site 3 - South Bank, Lumwana East River (UTM 373096 E, 8646340 N)

This site is located on a flat rock surface close to Site 2 and consists of 11 pock markings, 4 of which are arranged in the form of a square and the rest are random. The engravings have not been disturbed by human activity and are in good condition.

Site 4 - South Bank, Lumwana East River (UTM 373087 E, 8646345 N)

This site is a chance find where field assistant Mr. Kafupi was at one time in the company of an exploration geologist who discovered and collected a metal object shaped in the form of an axe. No surface objects or signs of human habitation were found during the current site survey.

Engravings are the most common type of rock paintings found in the North Western Province of Zambia. The engravings are formed by ‘pecking’ or ‘incision’ (scratching) with a hard piece of rock. The previous closest known engravings to the Lumwana Project are found at Kitungulu Hill approximately 28 Kilometres northeast of Chief Mukumbi’s Palace. The engravings found at Lumwana are likely contemporaneous with those at Kitungulu Hill and not associated with the traditions of people currently living in the area. It is likely that the engravings are the work of people that inhabited the area before the arrival of the Bantu-speaking people. These people were hunter-gatherers who were skilled at using the bow and poisoned arrow method of hunting. Quartz arrowheads are commonly found in the area. Rock engraving was probably a leisure time activity.

The rock shelters and engravings are located upstream of the Malundwe deposit and downstream of the area proposed for a tailings storage facility, but are likely to be affected by construction of a cross valley waste rock dump.

3.10.5 Natural Heritage Survey Results

No palaeontological or fossil heritage resources were identified during the survey. Two bat colonies were found in two caves. One cave is located on Malundwe Hill (UTM 372270 E, 8654550 N) and the second cave is located on an isolated hill above the Lumwana East River (UTM 373070 E, 8646450 N). The two sites are shown on Figure 3-11. The Malundwe Hill colony is outside and well to the north of the Malundwe open pit but the colony found close to the Lumwana East River and is within the proposed close to the proposed waste rock dumps of the Malundwe resource. Proposed mitigation measures are discussed in Section 5.

The copper flower (*Becium homblei)* is a rare small shrub with a pale blue flower. It grows in mineralised areas throughout the Central African Copperbelt and is an excellent indicator of copper rich soils. The flower contains a high copper content and only germinates in soils containing between 50 and 600 ppm copper. This greatly reduces the distribution of the plant. The plant’s close association with copper renders it vulnerable and endangered as more and more areas are cleared for mining. The copper flower occurs in abundance in the Malundwe copper clearing. Proposed mitigation measures are discussed in Section 5

Figure 3-11: Location of Cultural and Natural Heritage Sites

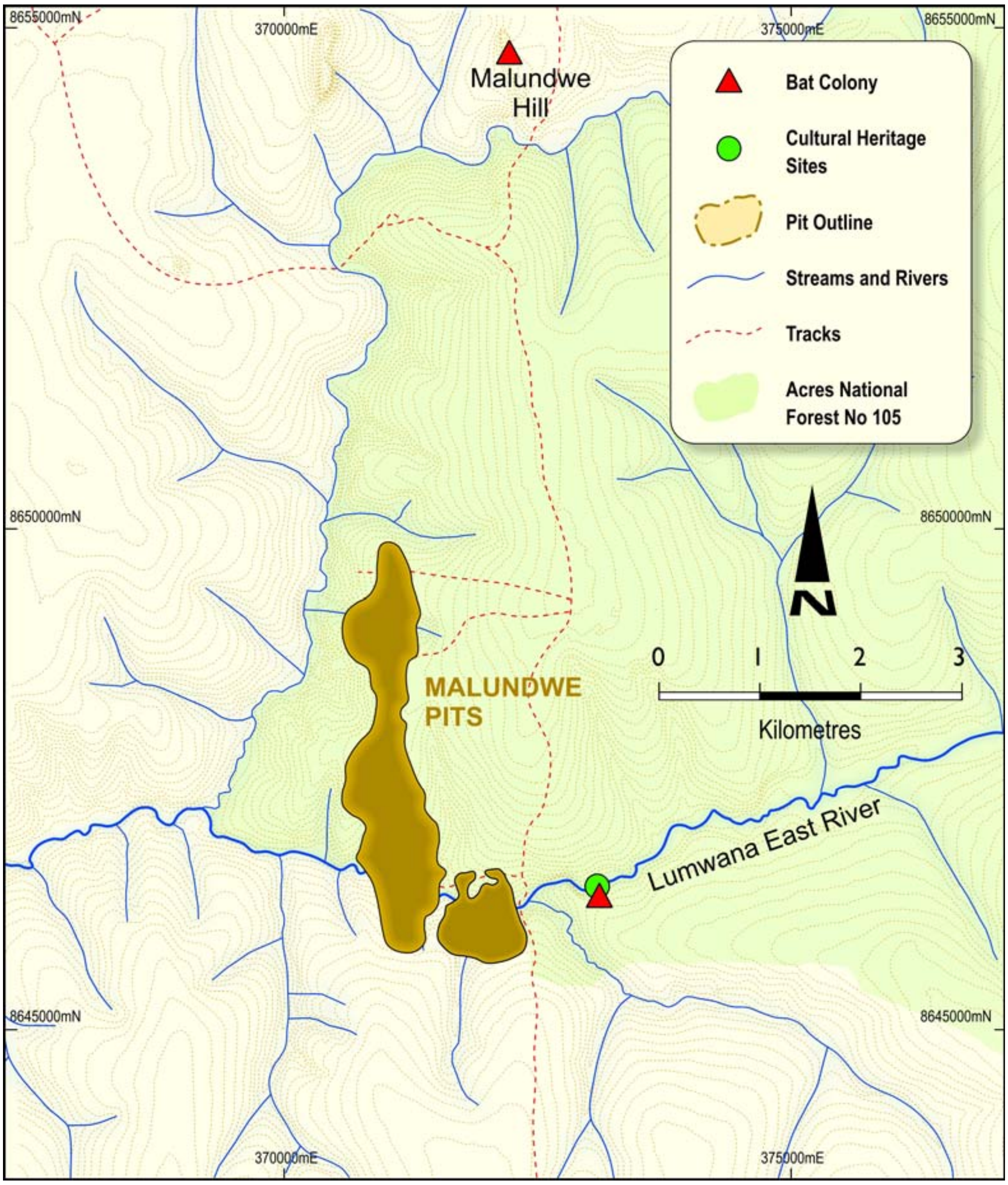


Plate 3.5: Rock Engravings at Lumwana Archaeological Site 2

A 7 metre high rock shelter on the Lumwana East River (Cultural Heritage Site 2) is the only geomorphological feature of note identified in the project area.

3.11 Land Use and Land Classification Evaluation

3.11.1 Introduction

Mr Mattias Fackel (AMC) carried out the land use and land classification evaluation including the fieldwork component between December 2001 and February 2002.

According to the map "Potential for Sustainable Development" (USDA, 1996) the Lumwana Copper Project falls within a zone of medium potential. A low potential for sustainable development is indicated immediately north of the project area. The potential for sustainable development according to the USDA is largely dependent on soil fertility. In the project area, soil fertility is low despite the good availability of water. Annual average rainfall is high (±1300 mm) and there is an abundant potential supply of surface water for irrigation agriculture from watercourses and groundwater. Agriculture is dominated by cassava (*Manihot esculenta)* cultivation. Cassava is an appropriate crop in soils with extremely low fertility and aluminium toxicity. Cassava is cultivated on relatively high ground in highly weathered and well-drained soils. Cassava is the most intensively farmed crop in the vicinity of the Malundwe and Chimiwungo copper deposits. Large cassava fields can be observed east and south of the Chimiwungo deposits in clearings of several hectares.

Maize and vegetables are grown in the Chimiwungo and East Lumwana dambo areas. Parts of the Kababisa stream basin are considered prime land and the cultivation of nutrient demanding crops is intense although confined to a small area of the dambo.

No pineapple cultivation was observed near the Malundwe and Chimiwungo deposits. Pineapple cultivation occurs in dambos close to the more densely populated settlements, which straddle the T-5 main road. The pineapple fruit is an important cash crop in the area.

Cultivated land is predominantly found near to the T-5 main road and the laterite road to Chief Mukumbi's village. The poor road infrastructure, limited transport network, small settlements sizes, and limited local markets control the extent of agriculture in the area rather than soil fertility and water availability.

3.11.2 Soil Classification and Capability

The Exploratory Soil Map of North Western Province, surveyed and compiled by the Soil Survey Unit, Mt. Mkulu, Zambia, was published in 1983. The scale is 1:500,000 and soils are classified according to the 1977 FAO/UNESCO classification.

A Soil Survey Unit reference pit (1983) for xanthic ferralsol is found immediately south of Chimiwungo deposits. AMC classified the soil at this location of the reference pit as an acric ferralsol (FAO-ISRIC-ISSS, 1998). The difference in classification is not significant and the results are considered to correspond.

A geric acrisol (AMC, 2001), north of the Chimiwungo deposit does not correspond to the Soil Survey Unit map. The scale of the survey from 1983 does not allow for very detailed soil descriptions. The soil profile classification indicates that acrisols and ferralsols occupy flat well-drained terrain i.e. most areas except for dambos and broken terrain.

The Soil Map of North Western Province does not account for alluvial soils. *Dystric regosols* although very limited in extent, do occur close to watercourses. These soils are also nutrient deficient but more fertile than the highly weathered upland soils.

Gleyic dystric cambisol occurs in dambo areas. The *cambisol* has relatively fertile topsoil. This soil type is considered suitable for maize and other nutrient demanding crops. However, the soil is seasonally waterlogged which impedes agricultural usage.

Table 3-29 summarises the soil types in the project area according to the Soil Map of North Western Province.

Table 3-29: Malundwe and Chimiwungo – Soil Types and Characteristics

Location / Soil Type	Soil Characteristics
Malundwe	
xanthic ferralsol	Extremely weathered, yellow, very deep, well drained gentle slopes and fine clayey texture.
acric ferralsol	Extremely weathered, very deep, well drained, gentle slopes, fine clayey texture, with alluvial sub-surface horizon.
with major inclusions of:-	
dystric gleyic cambisol	Seasonally waterlogged, infertile, deep, imperfectly drained, gentle slope, fine clayey texture.
orthic ferrasol	Extremely weathered, very deep, well drained, gentle slope, fine clayey texture.
ferric acrisol	Highly weathered illuvial soil, deep, moderately well drained, gentle slope, fine clayey texture with Fe-concretions.
Chimiwungo *xanthic ferralsol*	Extremely weathered, yellow, very deep, well drained, gentle slope, fine clayey texture.
with major inclusions of:- *dystric gleyic cambisol*	Seasonally waterlogged, infertile, deep, imperfectly drained, gentle slope, fine clayey texture.

Soil related constraints (Fahlén, 1997) for the two most common soil types found in the Malundwe and Chimiwungo areas are summarised in Table 3-30.

Ministry of Agriculture soil survey data was reviewed and verified by digging five soil pits and classifying the soils as part of the fieldwork programme. The location of the Malundwe and Chimiwungo soil pits are shown on Figures 3-12 and 3-13.

Table 3-28: Soil Constraints in the Malundwe and Chimiwungo Areas

Soil Type	Moderate Constraints	Severe Constraints
ferralsols	• Erosion • Water stress	• Compaction • Shallow rooting depth • Nutrient deficiency / imbalance • Plant toxicity
acrisols	• Erosion • Water stress • Trafficability and workability • Hard sub-surface layers	• Compaction • Surface crusting • Shallow rooting depth • Nutrient deficiency / imbalance • Plant toxicity

Soil classification was performed according to the World Reference Base for Soil Resources (FAO-ISRIC-ISSS 1998). Soil profile description and sampling practices followed the Guidelines for Soil Profile Description (FAO, 1977).

The classification is based on soil properties defined in terms of diagnostic horizons and characteristics observed in the field. Alfred H. Knight Laboratories in Kalulushi, Zambia performed the following chemical and physical analyses on soil samples.

- Cation Exchange Capacity (1M NH_4OAc);
- Base Saturation Percentage (1M NH_4OAc);
- Total Organic Content; and
- Percent clay.

The parameters listed above are qualifiers for classifying soil profiles into Reference Soil Groups and into lower level units. The parameters are also used to evaluate soil fertility.

FAO soil classification record sheets for the five soil pits (two at Malundwe - Mal/SPP-1 and Mal/SPP-02, and three at Chimiwungo - Chim/SPP-03, Chim/SPP-04 and Chim/SPP-05) are presented in Appendix O.

Figure3-12: Malundwe Soil Pits for Profiling

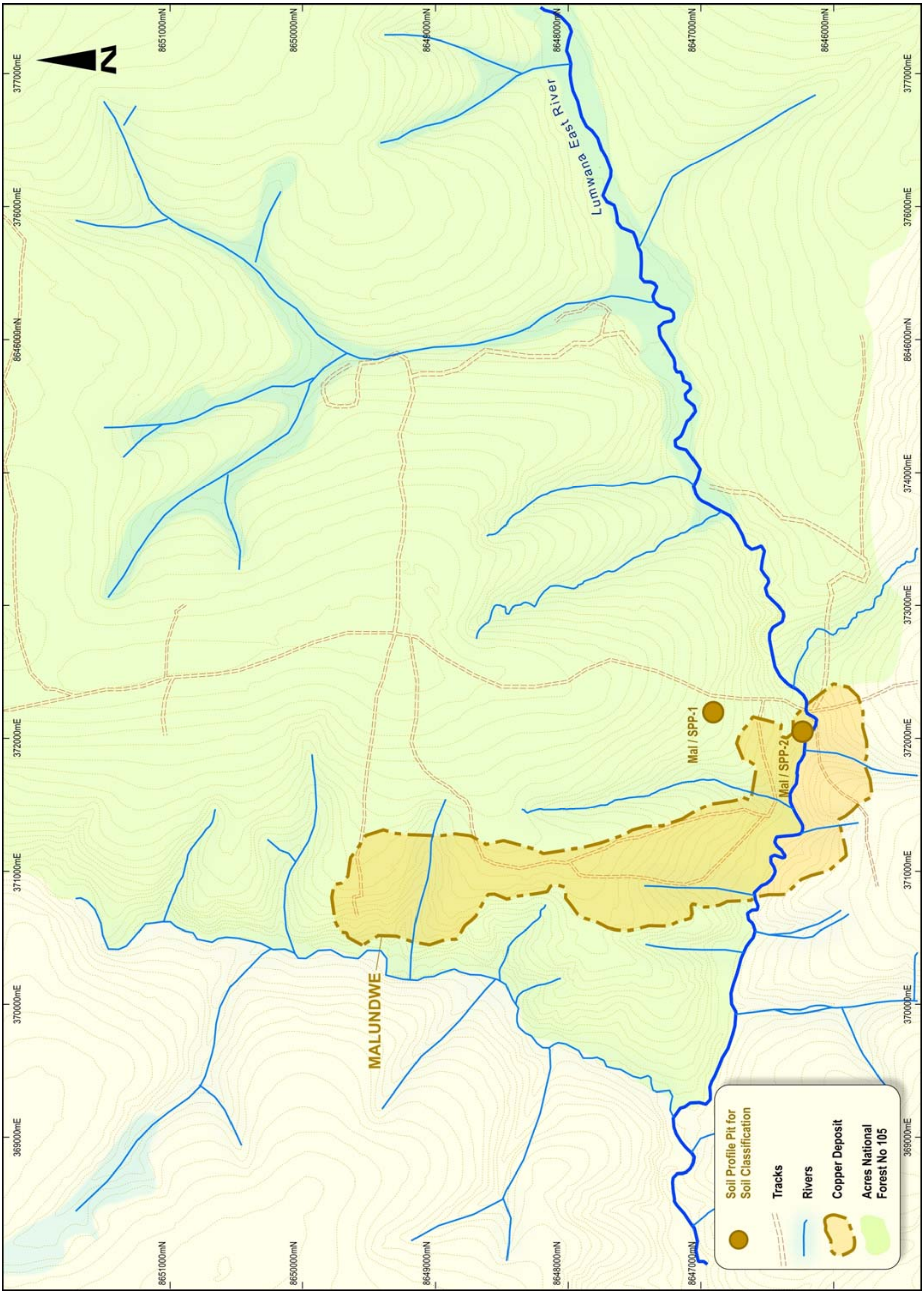
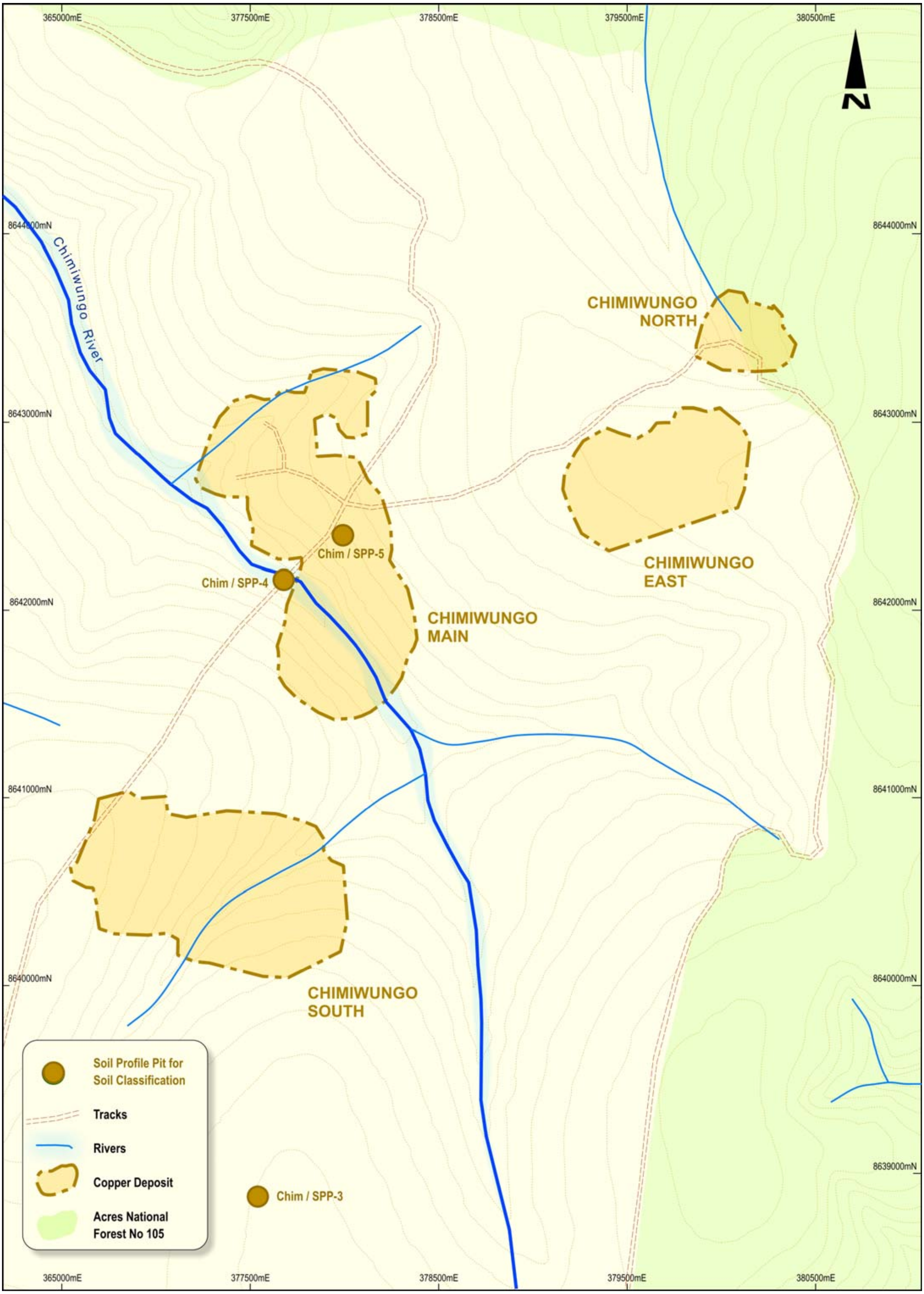


Figure 3-13: Chimiwungo Soil Pits for Profiling



The dystric regosol found on the north bank of Lumwana East River (Mal/SPP-02) is typical of the nature of alluvial soils near watercourses. The soil is nutrient deficient but more fertile than the highly weathered upland soils found elsewhere. Their extent in the project area is small and the soils are commonly found on or just above valley floors. Small plots of maize and sorghum were observed being cultivated in these soils.

A gleyic dystric cambisol in the Chimiwungo dambo (Chim/SPP-04) corresponds to the Soil Survey Unit (1983) classification. The cambisol has relatively fertile topsoil and the soil type is appropriate for growing vegetables and nutrient demanding crops. The soil is however, seasonally waterlogged, which precludes some agriculture uses. Maize and pumpkin is cultivated in the Chimiwungo dambo area and the Kababisa stream basin. Soil fertility characteristics are summarised in Table 3-31.

Table 3-31: Fertility Characteristics of Soil Types Found in the Project Area

Soil Type	Fertility Characteristics
Ferralsols	Extremely weathered soils, extremely low pH, high content of sesquioxides, very low nutrient reserves, low available water capacity. A soil found in areas of low relief.
3.11.2.1.1.1.1 Acrisols	Highly weathered alluvial soil, low base saturation, Al-toxic, low organic matter and nutrient poor. Found in areas of low relief**.**
dystric gleyic cambisol	Nutrient poor, seasonally waterlogged soil in dambos.
dystric regosol	Nutrient poor soil formed in recently deposited material.

3.11.3 Soil Geochemical Analysis

In addition to the soil classification pits an additional 16 shallow 300 mm deep pits were dug in the Malundwe and Chimiwungo area to collect near surface soil samples (0 - 150 mm depth) for soil geochemical analysis. Figures 3-14 and 3-15 show the location of these pits. The soil pit sites were chosen to cover the Lumwana project area but avoiding areas on or close to the copper deposits that have already undergone intensive geochemical study in past exploration programmes. A full suite of heavy metals is among the analysis conducted. Soil geochemical analysis (aqua-regia cold leach) was performed by A H Knight in Kalulushi. The soil sampling, storage and transportation protocol is described in Appendix J and the results of the soil geochemical analyses are presented in Appendix P.

All element concentrations in the near surface soils were as expected. Significant metal values included aluminium and iron with maximum concentrations of 9,600 mg/kg and 19,200 mg/kg respectively. Other significant element concentrations are boron - 68 mg/kg, barium - 37 mg/kg, copper - 100 mg/kg, magnesium - 437 mg/kg and manganese - 80 mg/kg.

3.11.4 Land Classification and Land Use

Satellite imagery was used to identify and map the distribution of 5 forms of land cover that occur in the Lumwana Large Scale Mining Licence (LML-49) area. Based on imagery interpretation and field observations, land cover in the area can generally be described as predominantly woodland dissected by rivers and streams with some riparian forest, and dambos. Rural settlements dominate along the T5 main road and site access tracks. There are no industrial or urban areas.

The five land cover classes were selected from observations made on the ground. These are dense woodland, woodland, riparian forest, dambo and settlement or cultivation. Land class, definition and image characteristics are described in Table 3-32.

A LANDSAT-7 Thematic Map quarter scene of the project area (scene centre, Lat. S 012° 06’53”, Long. E 025° 51’ 10”) was used to evaluate land use. The scene is 90km by 90km and is of good quality with no cloud cover. The imagery was acquired at 08:11:57am on the 28th of August 2001 and contains 7 spectral bands in the visible, infrared and thermal spectra and has a resolution of 30 metres for all channels (except panchromatic, with a resolution of 15 m).

Figure3-14: Malundwe Soil Pits – Geochemistry Survey Locations

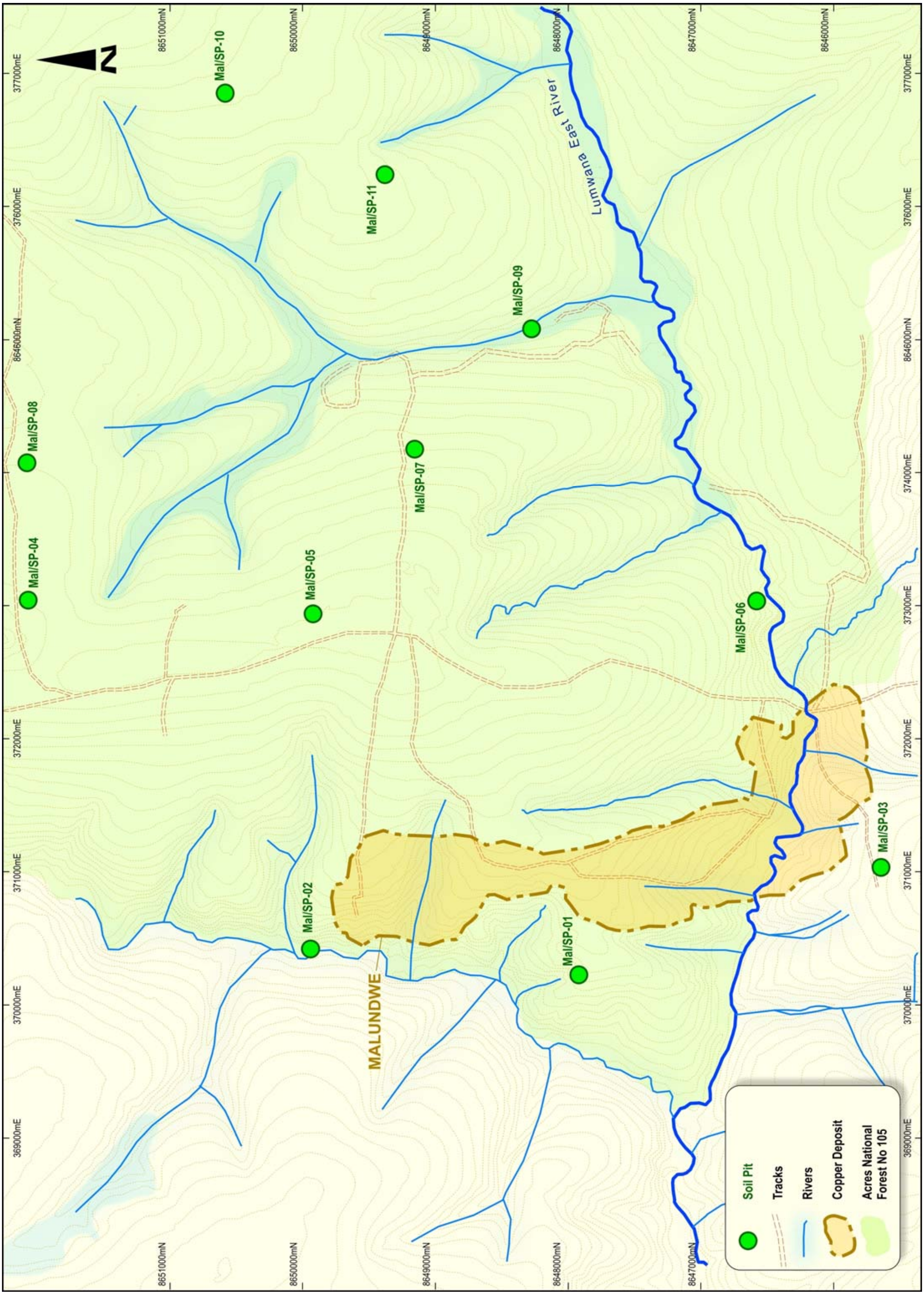
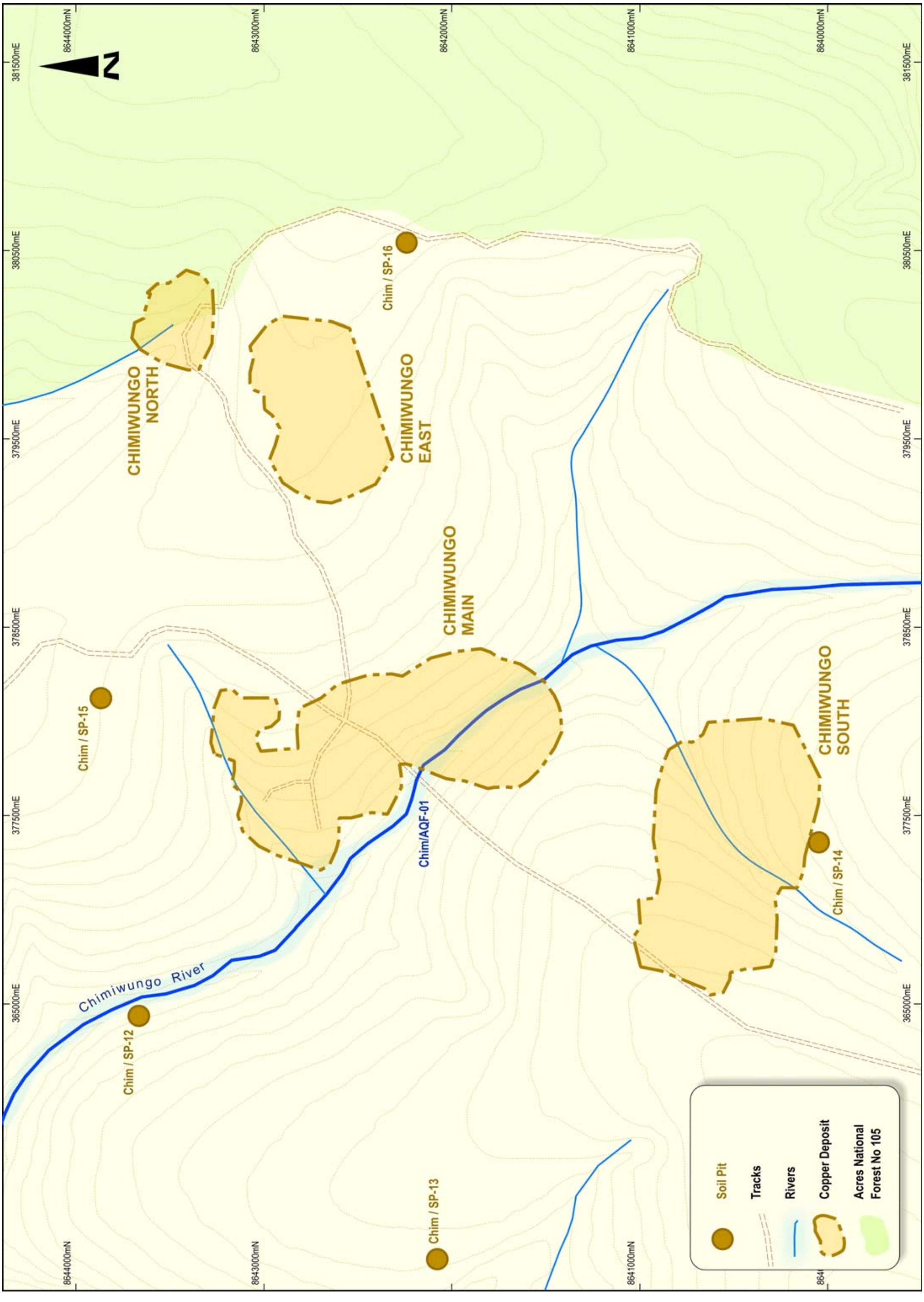


Figure 3-15: Chimiwungo Soil Pits – Geochemistry Survey Locations



Land classification is based on multi-spectral analysis and supervised classification using training sites and maximum likelihood classification.

Table 3-32: LANDSAT-7 Imagery - Land Class, Definition and Characteristics

Land Class	Definition	Image Characteristics.
Dense Woodland	Dense Miombo woodland. Often found in upland areas.	High reflectance in the near infrared spectral band, and only slight signal from soil. Fairly uniform large features.
Woodland	Less dense Miombo woodland, younger trees. Well distributed.	Reflectance in the near infrared spectral band with more signal form soil than in dense woodland. Large and uniform features.
Dambo	Waterlogged area possibly used for pineapple, rice and maize, cultivation. Limited to the river channel and seasonally water-logged.	Low reflectance in all spectral bands. Forming drainage networks.
Settlement / Cultivation	Land used for housing and crop production. Ploughed farmland and small rural villages along access routes.	High reflection in all bands. Forming large uniform features.
Riparian Forest	Very dense forest found along watercourses.	Very strong signal in the near-infrared spectrum as narrow strips along watercourses.

The total area of LML-49 is 135,500 hectares. Figure 3-16 shows the raw image in spectral bands 4, 3 and 2 or near infrared, red and green respectively and the land cover map showing the distribution of land classes and proportional land cover. The land cover image is the result of spectral signature analysis and maximum likelihood classification. Land class percentages in RL-01 are shown in Table 3-33.

The most intense land use is settlement and cultivation. However, Miombo woodland is used for bee keeping and dambos and wetland areas are used for pineapple growing. The dambo land class is also used seasonally for crop cultivation.

The dambo class includes wetlands in general and open water features such as rivers and lakes. Seasonal hydrological changes in the area are significant and the relationship between wetlands, lakes, rivers and dambos is dynamic.

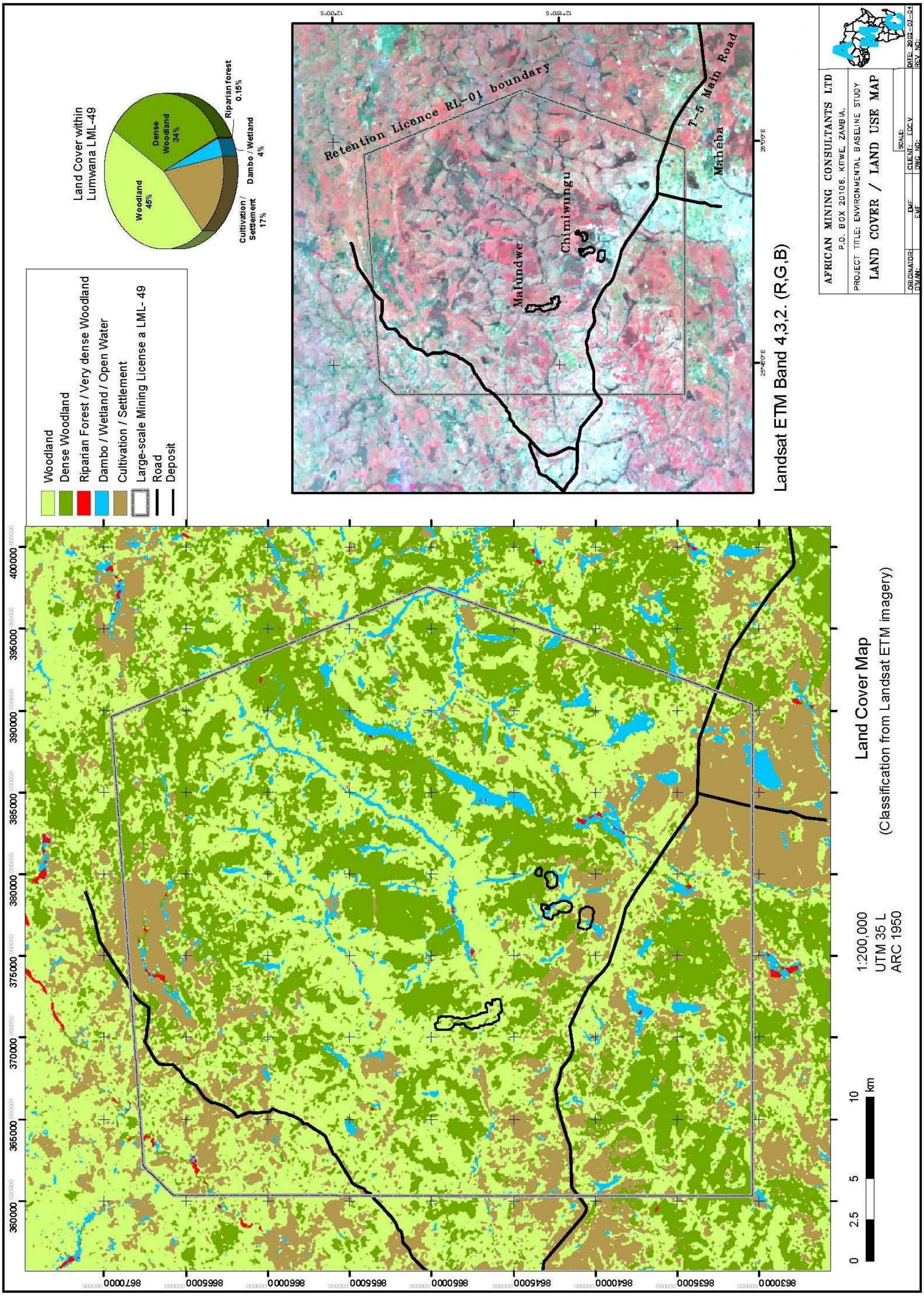
Table 3-33: RL-01 Land Class Percentage

Land Class	Percent Area of RL-01
Miombo Woodland	45%
Dense Miombo Woodland	34%
Settlement & Cultivation	17%
Dambo/Wetland	4%
Riparian Forest & very dense woodland	0.15%

Riparian forest is present along all watercourses. This forest type land cover is only shown on the land cover map (see Figure 3-16) where the vegetation type is extraordinarily extensive and may in some positions away from the drainage network be presented as very dense woodland.

Cultivation and settlement occurs mainly along lines of communication i.e. the T-5 main road, Meheba UNHCR refugee settlement, southern parts of the Chimiwungo deposit and the laterite road to Chief Mukumbi's Palace. There is no distinction made between cultivated land and settlements since the two land use categories are closely linked.

Figure 3-16: Land Cover/Land Use Map



It is important to note that the crop rotation of cassava in particular renders idle the major part of all cultivated land. Of the 45% cultivated land within the retention licence area, the majority is idle.

At the time of satellite image acquisition some parts of the area were burning. The smoke generated by the bush fires obscured some areas but the influence of this on the image was too small to be significant.

3.12 Background Radiation Survey

3.12.1 Introduction

The uranium mineral uraninite (UO_2) occurs in the project area. AGIP (Mineral Exploration Division) of Italy carried out an extensive diamond drilling campaign in the Lumwana area for uranium in the 1980's. More recent exploration drilling by Phelps Dodge has confirmed the occurrence of uranium oxide ore close to surface in the central portion of the Malundwe copper deposit. Due to the uranium occurrence, a background radiation survey (Geiger-Mueller Detector Survey) was conducted by AMC in the Malundwe and Chimiwungo areas.

3.12.2 Instrument

The instrument used to measure background radiation levels was a Dosimeter 3012 Probe connected to a Dosimeter 3007A Survey Meter. The detector is designed to measure medium and high-energy x-ray and gamma radiation and high-energy beta radiation.

3.12.3 Radiation Survey

The radiation survey initially focussed on the following areas:

- Locations where SRK (1996) or AMC (2001) reported high uranium levels in soil sampling;
- Old Reverse Circulation (RC) drilling sites;
- Copper clearings; and
- Sites, where exploration activity has occurred or low levels of uranium are reported in the soil.

At each survey location a 50 x 50 m^2 area was surveyed. The maximum reading obtained in the area was reported.

The unit of radiation used was milli Roentgen per hour (mR/hr). Roentgen is the unit used for measuring the quantity of x-ray or gamma radiation by quantifying the amount of ionisation produced in air. If human tissue absorbs one Roentgen of radiation, 96 ergs of energy will be deposited per gram of tissue. The results taken were converted to Radiation Equivalent Man (REM) measured in milli Sieverts per year. This is the unit of effective radiation dose and is the most commonly used international unit for radiation measurement.

The following formula was used to convert mR to mSv

mSv = 0.96 mR / 100a, where :

mSv = milli Seiverts, mR = milli Roentgen and a = Quality Factor (amount of energy created in human tissue after exposure to radiation)

The average background radiation in the project area was measured as 3.96 mSv/year.

The sampling sites and background radiation measurements for the Malundwe and Chimiwungo areas are presented in Table 3-34.

The average United States citizen is exposed to 3.60 mSv/year from all sources of radiation, including radon and medical exposure (USDoE, 2000)

Table 3-34: Background Radiation Measurements for the Malundwe / Chimiwungo Area

Monitoring Sites	GPS UTM Co-ordinates		Radiation mSv/year
	Easting	Northing	
South of Malundwe deposit at maximum uranium concentration in soil (SRK).	372390	8645630	2.5
Lumwana East River at Lum/SW-01.	372235	8646296	2.5
East of Malundwe deposit, at maximum Uranium concentration in soil (AMC/SRK).	373000	8646610	4.2
Southern part of Malundwe copper deposit.	371790	8646480	2.5
At exploration trenches in Malundwe South copper clearance.	371460	8646610	4.2
At exploration drill hole.	370090	8646770	4.2
At Kababisa Stream, Lum/SW-04.	375047	8648662	2.5
At exploration drill hole.	380970	8648340	4.2
North of Malundwe copper deposit.	372380	8651740	4.2
North of Malundwe copper deposit.	373670	8652120	7.6
East of Malundwe copper deposit.	372322	8646595	1.7
South East of Malundwe copper deposit Along Chimiwungo Stream.	373337	8645380	4.2
North side of Chimiwungo south deposit.	376997	8641289	5.1
West side of Chimiwungo north deposit.	377408	8641930	5.9

Radiation survey readings were made at the lower end of the probe's range and the efficiency of the Probe in that range is unknown. The efficiency of the probe was assumed to be 100% i.e. 1 count per second equals 1 disintegration per second.

Results of the radiation survey indicate that the background radiation levels measured within the Lumwana project area are low and do not pose a danger to human health.

3.13 Noise and Vibration

There is no historical noise data for the Lumwana area. Due to the remote location of the Malundwe and Chimiwungo deposits and absence of infrastructure and industry, the highest noise levels are currently associated with the natural elements i.e. wind, rain and thunderstorms. However, the presence of a significant number of trees and the capacity of the rolling landscape to absorb sound pressure from these sources means that noise levels are low. Daytime noise levels based on the $L_{A90.T}$ Index are estimated to be between 30 and 40 decibels (dB). These are extremely low noise levels.

It is estimated that noise levels in local villages such as Mafuta Village situated some 4.5 kilometres from the Malundwe deposit may reach 55 dB during periods of social activity but the average daytime background noise level is likely to be closer to 45 - 50 dB. Due to the absence of electricity in the rural setting, evening noise peaks tend to drop off as darkness falls and inhabitants prepare for sleep. Night background noise levels are likely to be between 30 and 35 dB (A).

Noise from road traffic is negligible because of the short duration and extremely low traffic volumes in the area.
The sources of vibration in the area can be attributed to vehicles on the T-5 main road. The surrounding topography and geology act to absorb vibration. Current vibration levels are considered to be negligible and insignificant.

3.14 Infrastructure and Communications

Surface infrastructure in the project area is limited. There is no railway line. The T5 tar road from Solwezi to Mwinilunga passes close to the southern portion of the project area. The road has good stretches and poor stretches that are potholed. Apart from the laterite road to Mukumbi Lubinga (Chief Mukumbi's Palace) there are no other gazetted roads in the area. Previous exploration companies constructed tracks through the Malundwe and Chimiwungo areas, which have become established 'rights of way'. A series of rural villages straddle the T5 road as it crosses the retention licence area. Water supply to these villages is from wells sunk by the Department of Water Affairs. There are no sewage treatment plants in the area and pit latrines are common.

The national power grid, small-scale hydroelectric power stations and large diesel generators provide electrical power in the North Western Province of Zambia. The national grid serves only a narrow corridor extending from the Copperbelt to Solwezi. Beyond Solwezi, electricity is supplied to the larger towns by diesel generators and local hydro-electricity schemes. There is no electricity supply in the Lumwana area. Diesel generators provide power to the ECV Lumwana Base Camp and Malundwe Geologists Camp.

Land and mobile phone telecommunication services are absent west of Solwezi. Radio communication is maintained between various agencies at the UNHCR Meheba refugee camp and Solwezi. The airstrip to the north of Chief Mukumbi's Palace was in the past in radio communication with Solwezi but the current status of this radio link is not known. ECV Lumwana Base Camp is equipped with a satellite telephone.

3.15 Socio-Cultural and Economic Study

3.15.1 Introduction

Environmental consultant Dr. Mutilo Silengo, who is also Academic Coordinator, Leadership for Environment and Development (LEAD), Southern Africa, Lusaka, undertook the baseline socio-cultural-economic study of the project area. Mr. N Armitage, AMC environmental scientist assisted Dr Silengo. The field component of the study was conducted between 27 and 31 January 2002.

3.15.2 Approach and Methodology

The approach to the socio-economic baseline study was participatory, in line with World Bank and International Finance Corporation (IFC) guidelines.

The first phase of the study was to review available secondary information. In the next phase, the participatory rural appraisal (PRA) methodology was employed to collect socio-cultural and economic field data.

The following research process was adopted:

- Review available secondary documentation;
- Site visits to Solwezi Town and Lumwana East;
- Conduct the PRA in the local community;
- Meetings with community leaders; and
- Conduct interviews with key informants and stakeholders.

Tools and techniques used to engage the community and gather information are listed in Table 3-35.

Table 3-35: Tools and Techniques Used to Engage the Community and gather information

Tools Used	Technique Used
• Resource mapping • Seasonal calendar • Semi-structured interviews • Livelihood analysis • Venn diagram • Daily activity done	• Group discussions • Group discussions • Discussion with key informants • Group discussions • Group discussions • Discussion with people

3.15.3 Community Meeting

A community meeting was held to:

- Share basic information concerning the project;
- Identify issues and outline the concerns of the affected communities;
- Invite the local communities input to the project; and
- Build support for the project.

Notes on the PRA community meetings are presented in Appendix Q.

3.15.4 Country Overview

The Republic of Zambia government system is a multi-party democracy. The 150-member National Assembly, elected by universal suffrage, represents the national legislature. The President is the Head of State governing the nation via his appointed Cabinet. The legal system is based on English common law and customary law. The country is divided into 9 political subdivisions referred to as Provinces.

The Zambian economy has always been dependent on foreign exchange revenue from its extractive industry. Copper accounts for over 75 percent of export earnings. The decade immediately after political independence saw a collapse in copper prices. State controlled economic policies introduced in the early 1970s had a devastating effect on the Zambian economy. Since then, the country has experienced a steady decline in its economic performance, with per capita income falling, almost 5 percent annually from 1974 through the 1990s.

Zambia has also suffered economically because of its ‘land locked’ location and proximity to southern Africa's recent hotspots - the Democratic Republic of Congo, Zimbabwe and Angola. The constant arrival of new refugees and ex-combatants is a cause for concern because of the country’s weak economy and poverty rating.

Zambia has however, made significant progress in implementing ambitious economic reforms, including privatisation, deregulation and exchange and trade liberalisation. Indications are that hyperinflation has been contained and economic management has improved. These steps have yet to be reflected in sustained economic growth and Zambia remains one of the poorest countries in the world. Social indicators remain persistently low and a high incidence of HIV/AIDS presents further challenges to Zambia's poverty reduction efforts. It is estimated that 73 percent of the population live below the national poverty line. The government has undertaken a number of institutional reforms in social sectors and has put forward a broad strategy for growth and poverty reduction in its Poverty Reduction and Strategy Paper presented to the IMF in 2002, including implementation of HIV/AIDS programmes. The Human Development Index (HDI) is 0.376. Life expectancy at birth is 33.4 years. Adult literacy rates stand at 79.0 percent (% age 15 and above) (UNDP, 2000).

3.15.5 Provincial Government and Administration

Solwezi is the Provincial Headquarters of North Western Province. The province had an estimated population of 610,975 people in 2000 mainly comprised of small-scale farmers. Since colonial times North Western Province has been known as one of the least developed regions of Zambia, and the Solwezi area is no exception. The Province, endowed with good rainfall and soil, is remote from the more industrialised Copperbelt and has no large-scale commercial farming. The Province has poor roads infrastructure and has not attracted any major investment in recent decades.

Other large towns include Mwinilunga, which is situated in the NW corner of the province, 276km from Solwezi; Kasempa, located 165km south of Solwezi; Kabompo, which is 340km southwest of Solwezi and Zambezi, which is 517km southwest of Solwezi.

3.15.6 Traditional Government and Administration

The traditional system of governance is an important part of the way of life in the rural areas. The Chief administers his area using group tribal leaders, village headmen and a system of deputies. They address typical issues of local importance, for example, issues relating to land or witchcraft.

Chief Mukumbi, whose area covers Lumwana East, has 18 Group Leaders (3 of these are in the immediate vicinity of the project area from Manyama School West to the Equinox Copper Ventures base camp, namely Group Leaders Kisonge, Kaumba and Mafuta), and 21 sub deputies. A legal structure is also present in the traditional communities. There are Local Courts with Court Assessors who are appointed on the recommendation of the Chief and district government.

3.15.7 Population: North Western Province

The 2000 Population Census shows that the population of North Western Province has increased from 438,216 in 1990 to 610,975 in 2000 an average annual growth rate of 3.4 percent. Despite this high growth rate, the Province has the lowest population in the country, accounting for just 5.9 percent of the total population in the country. It also has the lowest population density at 4.9 persons per km^2. Solwezi District has the largest share of the provincial population with 33.4 percent. The average annual population growth-rate in Solwezi, which has been augmented in the last three decades by the spontaneous settlement of immigrants from neighbouring countries, is 4%. Population distribution in the North Western Province is summarised in Table 3-36.

Table 3-36: Population Distribution in the North Western Province of Zambia, 2000

District	Households	Males	Females	Population
Chavuma	6,931	15,886	17,160	33,046
Kabompo	13,654	37,285	38,378	75,663
Kasempa	9,140	27,564	28,330	55,894
Mufumbwe	7,563	21,666	22,196	43,862
Mwinilunga	23,138	65,131	66,384	131,515
Solwezi	39,971	101,508	102,793	*204,301
Zambezi	12,483	32,556	34,138	66,694
North Western Province	112,880	301,596	309,379	610,975

Source: Central Statistical Office, Report 2000 - Census of Population and Housing.
** Includes Meheba Refuge Population.*

3.15.8 Refugee Population: Meheba UNHCR Refugee Settlement

Zambia hosts more than 270,000 refugees, mostly from Angola and the Democratic Republic of Congo. According to UNHCR sources, Angolans now account for more than 200,000 of the total refugees currently hosted by Zambia. The Meheba refugee settlement, situated approximately 70km from Solwezi and 30 km from the Lumwana project area, was officially opened in 1971. It has had an important social impact and is therefore described in some detail here.

Meheba was originally set up as an agricultural settlement and now comprises an area of 820 km^2 on which in 2000 more than 58,000 people resided. It is a collection of villages in the middle of the 'bush', similar to those found in the rest of Zambia. The majority of the refugees arrived from Angola in the 1970's following the outbreak of the Angolan civil war. In the 1990's, approximately 2000 Congolese fleeing the war in the Democratic Republic of Congo, 2,500 Rwandans and 580 Burundi sought shelter in Meheba. At the end of 1998, 50.3% of the inhabitants were female, 43.8% were children and young people (15.8% under five) and 5.9% were aged 60 or more. The total refugee population at the end of January 2002 was 58,535.

In line with the integration strategy of self-sufficiency, all new arrivals receive 2.5 hectares of land on which to build a house and to farm. They are also provided with tools and seed. During the first two harvests (the first two years) the refugees receive food rations (13.5 kg of maize, 3.6 kg of beans, 600 g of oil and 300 g of salt per person per month). At the end of the two year period they are required to live off what they produce themselves from their plot of land.

The main livelihood is agriculture and small business, although projects are underway to promote bee keeping and fish farming (in fishponds) at a sustainable level. The main crops grown in Meheba are cassava, maize, sweet potatoes and various types of vegetables. A large part of the sweet potato harvest is sold both within Zambia and the neighbouring countries. With a harvest of over 10 000 metric tons of maize (1997) Meheba has a significant share in the agricultural production in Zambia. Lutheran World Federation officials believe refugees are exploited by local businessmen because they cannot afford to transport their produce to market, and therefore have to accept lower than market prices. Refugees are now being encouraged to establish co-operatives to enable them to negotiate better prices for their goods.

Meheba has a secondary school and five primary schools. These, together with five clinics are administered and equipped by the Zambian government. There are 326 water points (mainly wells and boreholes) in the settlement.

The Lutheran World Federation / Zambia Christian Refugee Service (LWF / ZCRS) has been appointed by the UNHCR, as the only non-governmental organisation, to provide logistics in Meheba. This includes the maintenance of infrastructure and the provision of services such as agricultural advice, support to the vulnerable sections of the refugee population (the elderly, the disabled and orphans) and the implementation of measures to generate income and promote a sense of community.

Other active organisations without UNHCR funding include the Jesuit Refugee Services (JRS), the Zambian Red Cross, the Young Men's Christian Association (YMCA), the Japanese Association to Aid Refugees (AAR) and CARE International. AAR and JRS make a major contribution through educational and vocational programmes and their involvement in income generating projects.

Interaction between refugees and the local community is encouraged and unrestricted. Inter-marriages are also common because the Lunda and Luvale tribes extend from Zambia into Angola and so many of the refugees share similar cultural practices with the local people.

Although refugees are encouraged to live in harmony with the local people, some resentment was expressed at the community meeting attended by the local people. Refugees were perceived as land grabbing, and engaged in poaching and stealing.

Repatriation of refugees has been ongoing with approximately 310,000 refugees returning to Angola since 2002 (from Meheba and other camps in the Democratic Republic of the Congo and Namibia). Repatriation is due to be completed at the end of 2005 with a further 53,000 Angolan refugees to be repatriated by this time (UHHCR, 2005). Options for use of the infrastructure at the camp once all refugees have been repatriated are still being considered by the GRZ, among them a camp for the elderly and vocational training facilities (IRIN, 2005)

3.15.9 Social Fabric and Structure

Ethnic-Tribal Groupings

North Western Province has a diverse mix of ethnic or tribal groupings with their corresponding Bantoid languages. The principal ethnic groups and their languages are given in Table 3-37.

Table 3-37: Ethnic Groups and Languages of North Western Province (SIL, 2002)

Ethnic Group	Language
KACHOKWE	Chokwe language is also spoken in Angola, Namibia and DRC.
KAONDE The Kaonde People are found in Solwezi, Kasempa and Chizera districts of North Western Province and Kaoma in Western Province. The Kaonde, like the Lunda are the descendants of the famous Luba-Lunda Empire of Congo. The Kaonde were among the first Zambian tribes to carry out the mining of copper. Archaeological evidence at the Kansanshi Mine in Solwezi dates back to the Zambia Iron Age.	Language is Kaonde or KiKaonde and is not closely related to other languages. The language is used for literacy campaigns and agricultural extension services. It is officially taught in primary schools and used in newspapers, radio and television programs. Kaonde is also spoken in the DRC.
LUNCHAZI	Chiluchazi / Lucazi language is also spoken in Angola.
LUNDA Now living in the Luapula area and North Western Province, the Lunda people are descendants of the original Mwata Yamvwa Chieftainship in Congo.	The language is Chilunda with its many dialects. This is distinct from Lunda, a dialect of Bemba. It is used for literacy campaigns and agricultural extension services. It is officially taught in primary schools and used in newspapers, radio and television programs. It is also spoken in Angola and the DRC.
LUVALE Originally coming from the North of Lake Tanganyika, their first chief was a woman named Kenga Naweji. Descendants of these people are the Valuvale, Valuchase, Vambunda, Vachokwe and Vaviya Tribes living in the North Western Provinces. The Luvale were for centuries, great travellers and traders. Much of their culture recalls their contact with the Portuguese on the Angolan coast, five hundred years ago.	Alternate language names are Luena, Lubale and Lovale. It is a language of wider communication used in newspapers, radio and television programs. It is also spoken in Angola.
MBUNDA	Alternate language names are Mbunda, Chimbunda and Kimunda. It is also spoken in Angola.

The main tribes in Chief Mukumbi's area are Kaonde, Lunda, Luvale, Chokwe, Mbunda, Luchazi and to a less extent Bemba.

The main language spoken is Kaonde. The Kaonde language is officially taught in schools. It is also used in literacy campaigns, agricultural extension services, newspapers and radio programmes. Lunda is also widely used. Intermarriages across tribal lines are common and people usually live together in harmony.

The Kufukwila Ceremony is the main annual ceremonial event observed in mid-May to thank God and ancestors for the land and harvest. The ceremony is conducted at traditional sites including a shrine near Chief Mukumbi's Palace. The traditional ceremonies that take place in North Western Province are given listed in Table 3-38.

Table 3-38: Traditional Ceremonies in North Western Province

Tribe	Ceremony	Description
KAONDE	Kufukwila	In May, the Kaonde tribe and their Chief Mukumbi celebrate this festival in the Solwezi District of North Western Province.
LUVALE	Likumbe Liyamize	In July, the Luvale people of the Zambezi District in North Western Province come together to celebrate their cultural heritage at Mize, the official palace of Senior Chief Ndungu. King Kayipu, named after a famous chief, leads Makishi dancers representing figures from tribal mythology. The Makishi play an important part in the traditional rite of circumcision.

Kinship and Culture

The village among Kaondes is a family based unit. The personal identity of the family unit is very important in defining the village entity. Village houses are often built of adobe brick with thatch roof (see Plate 3.6). Some houses are constructed using poles and plastered mud. The number of houses in the village set-up is normally arranged according to the number of elderly people in that family. The parents will occupy a single dwelling, usually the largest in the homestead. In the case of a polygamous family, both the senior and junior wives will have their own houses. Older male and female members of the family will occupy different quarters. The *Chota* (meeting/eating place) is centrally located and is usually used by males as an eating-place and for discussions. Female members of the family sit in this area by invitation only. The *Kinzanza* is the domain of women and is used for cooking.

Chief Mukumbi Ibaloli oversees traditional governance in his chiefdom, which covers the project area. He is assisted by *ba Kitumbafumo* (Group Leaders) and *ba Mwinemuzi* (Village Headmen). These Leaders and headmen preside over matters affecting people in his chiefdom.

Plate 3.6: Typical adobe brick 'house' or huts construction – Mafuta Village

Religious Practices and Beliefs

From a general survey of the area, it is estimated that over 80% of local people embrace the Christian faith. A number of churches have been established, sometimes located less than 1 km apart along the main Solwezi - Mwinilunga road. It is quite evident that religion is an important aspect of peoples' lives and therefore the Church is a very important institution in these communities. Christian religions and traditional philosophies co-exist, and witchcraft is a common belief.

A survey of churches in the project area revealed fourteen denominations:

1. United Methodist Church;
2. Roman Catholic Church;
3. Covenant Church;
4. Christian Brethren (CMML);
5. New Covenant Church;
6. Seventh Day Adventist Church;
7. Pentecostal Assemblies of God;
8. Evangelical Church of Zambia;
9. Open Church;
10. Christian Community Church;
11. New Apostolic Church;
12. Baptist;
13. Jehovah's Witnesses; and
14. Jordan Church.

Livelihoods

An indication of the livelihoods of people living in the project area is given by the rural seasonal calendar. The calendar is dominated by farming activities highlighting the fact that local peoples' lives are strongly influenced by agriculture and related activities. See Table 3-39.

Figure 3-17 is a Participatory Resource Map Showing the Group Leader Areas and the extent of farming in the area.

Table 3-39: Rural Calendar in the Project Area (Agricultural Cycle)

Month	Farming Activities
January - March (Wet Season)	Plant pumpkins and sweet potatoes. Picking of various types of mushroom found in the area. Weeding of fields. Sweet potato harvesting, Jimbo, Ntamba, and beans harvesting and first green maize cobs.
April - July (Cool, Dry Season)	'Scaring' Birds. Harvesting of maize. Women cut thatch grass. Houses are built or repaired.
August - September (Cool, Dry Season)	Preparation of River Gardens for green vegetables.
October - December (Hot, Wet Season)	Clearing bush and lopping trees for the Chitemene farming system. Ploughing fields. Cassava, Maize, Sorghum, Millet and Groundnuts are planted. Picking of mushrooms (including Bandele and Bakulumbwe) and wild fruits like Masuku and Fungo (*Uapaca Kirkina* and *Anisophyllea Boehmii*)

The major economic activities in Lumwana East include subsistence farming and other, non-farming activities. Accordingly, livelihood strategies can be grouped into:

1. Natural resource based.
2. Non-natural resource based.

The different livelihood strategies are presented in Table 3-40.

3.15.10 Agriculture, Commerce and Industry

Agriculture is practiced on a subsistence level using the traditional *Masala* method (slash-and-burn). This is the main source of livelihood. Crops grown include maize, millet, sorghum, cassava, sweet potatoes, beans and pineapples. Livestock rearing is also done with the main animals being goats, pigs, sheep and chickens. Goats are reared in large numbers, primarily for the DRC market. Few people rear cattle in the area. Being traditional rural communities the land usage reflects the dominant occupation of the people.

There are no major industries in the area. Consequently, commerce is mainly related to trade in agricultural produce and petty trading in household consumer goods. The major markets for produce are Solwezi town, the Copperbelt and Lusaka.

Figure 3-17: Particpatory Rural Appraisal Resource Map

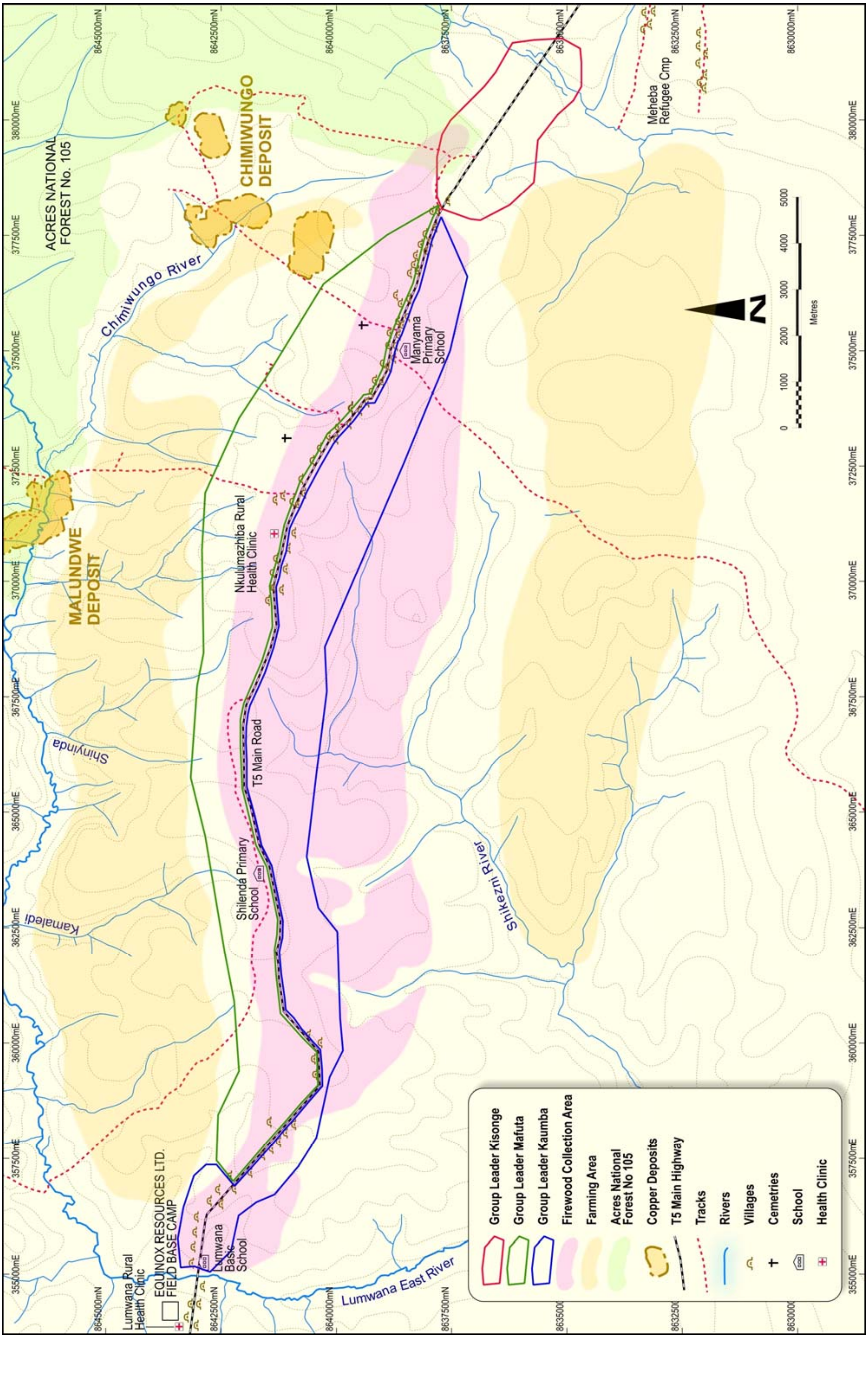


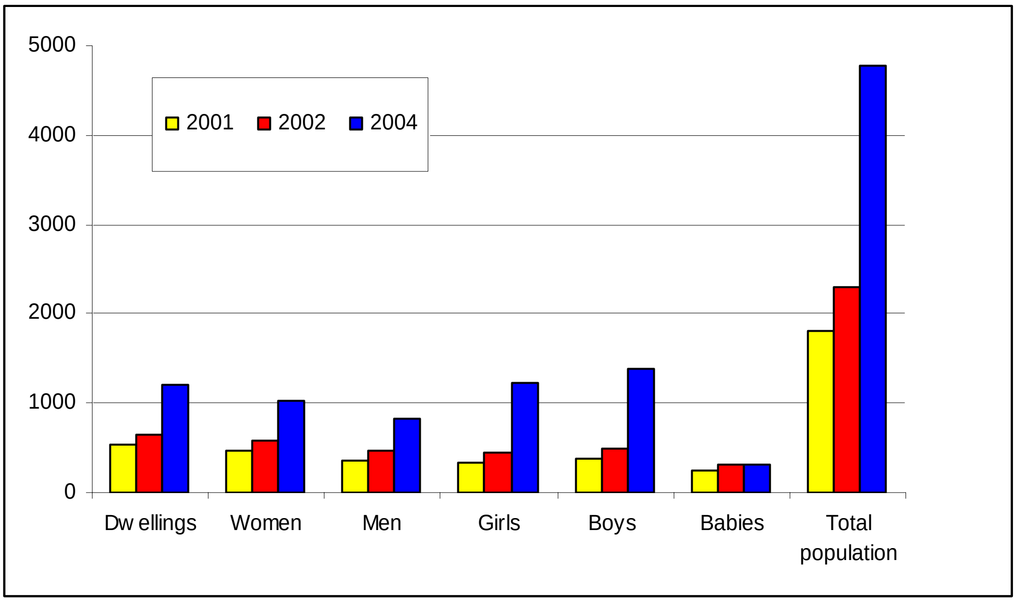
Table 3-40: Livelihood Strategies in Lumwana East

Livelihood Strategies (economic activities)	
Natural Resource Based	**Non-Natural Resource Based**
• Subsistence agriculture • Market gardening • Charcoal production • Fishing • Mushroom collection / selling • Basket weaving and crafts • Traditional healing	• Market or roadside vending • Beer brewing (*Imbote* gin) • *Munkoyo* brewing (maize or sorghum • based beverage) • Petty trading in *Tuntemba* (roadside kiosks) • Blacksmithing / tinsmith • Livestock rearing

3.15.11 Population in the Vicinity of the Project

ECV carried out a detailed census of houses / huts and population in the immediate project area (Malundwe and Chimiwungo villages) in 2001, 2002 and 2004. There has been a steady increase in the total population over this time. Since the first census in 2001, population was 1,801 with 529 dwellings. By 2004 this had increased to 4,779 people in 1,209 dwellings. Population demographics are shown in Figure 3-18.

Figure 3-18: Malundwe-Chimiwungo Population 2001-2004



3.15.12 Social Infrastructure

Education and Schools

The North Western Province has a total of 466 schools (as at 2001). The breakdown of school type by Provincial District is presented in Table 3-41.

Chief Mukumbi's area has 8 Basic Schools. Middle Basic Schools offer education from Grades 1 to 7, while Upper Basic Schools run from Grades 1 to 9. Ministry of Education Staffing Levels in the provincial schools is given in Table 3-42 and the names of these schools and pupil attendance figures are given in Table 3-43.

It is important to note that these villagers live alongside the T5 highway, not on the project site and therefore relocation will not be required.

Table 3-41: Schools in North Western Province

Provincial District	Educational Establishment/School Type					
	Primary School	Upper Basic	Senior School	Community	Secondary	Colleges
Chavuma	17	2	0	0	1	0
Zambezi	37	11	3	0	3	0
Kabompo	50	11	1	13	2	0
Mufumbwe	22	6	0	0	1	0
Kasempa	30	12	0	8	3	0
Solwezi	85	27	3	24	6	1
Mwinilunga	54	13	2	10	6	0
Total	295	84	9	55	22	1
Drop-Out Rate from Grade 1 - 6 per annum is 2.5% boys and 2.4% girls						

Source: Ministry of Education (Provincial) 2001

Table 3-42: Ministry of Education Staffing Levels in North Western Province

Area	Primary Teachers	Positions Vacant	Secondary Teachers	Positions Vacant	Total No. Teachers
Solwezi	673	243	136	10	809
NW Province	1,842	777	428	37	2,270

Source: Ministry of Education (Provincial) 2001

Teachers spoken to at community meetings indicated that there is a high drop-out rate at Grade 5-6 mainly due to early marriages, long distances travelled to school on foot and lack of money to pay school fees. The drop-out rates tend to be higher among girls. This is reflected in the relative gender attendance figures in Table 3-43.

Table 3-43: Schools in Chief Mukumbi's Area

School	Boys	Girls
Lumwana East Upper Basic	228	199
Lubinga Middle Basic	108	60
Manyama Upper Basic	209	183
Shilenda Upper Basic	121	80
Mukumbi Basic	276	290
Shinda Middle basic	176	134
Mukonzhi Middle Basic	94	80
Luanvundu Upper Basic	158	116
Totals	1,370	1,142

Source: Ministry of Education (Provincial) 2001

3.15.13 Medical Facilities: Rural Health Centres

The existing policy on the location of rural health centres (RHCs) is that they should be established at 15 km intervals. There are seven RHCs in the project area, six operated by government and one by the Catholic Church. The RHCs provide primary health care services, including antenatal, maternity and under-five services. The seven RHCs are Mangala Rural Health Centre, Kyanika Rural Health Centre, Mumbhezi ZNS Rural Health Centre, Mukumbi Rural Health Centre, Lumwana East Rural Health Centre, Holy Family Rural Health Centre and Kalengelenge Rural Health Centre. The Catholic Church Primary Health Service provides complimentary services for under-five clinics, antenatal clinics and home-based care for terminally ill patients. Some of the centres have a large catchment such as Lumwana East RHC which caters for up to 11,000 people. Beginning in 2002, ECV, with the support and assistance of the District Commissioner and Chief Mukumbi, built an RHC which included a day clinic, accommodation for medical staff and ablution facilities.

The main challenges facing the provision of effective health care services in the area are poor roads and long distances making attendance difficult for many people. For example, it is not uncommon in some instances for patients to travel on foot for up to 12 km to the nearest health centre. The centres face poor staffing levels, inadequate funding and unreliable transport. The poor health centre staffing levels are illustrated by the Solwezi District statistics presented in Table 3-43. Referral cases in the area are sent to Solwezi General Hospital, Mukinge Hospital in Kasempa or Mwinilunga Hospital.

Table 3-44: Health Centres & Staffing - Solwezi District (excluding provincial hospital)

No. of Health Centres		Health Staffing Levels		
Rural Health Centres	Mission Clinics	Doctors	Nurses	Registered Nurses
39	3	1 (Solwezi) 1 (Meheba)	61	4

Source: Ministry of Health, Solwezi District 2002

Malaria is the most common illness. Other common diseases are diarrhoea and anemia, frequently associated with malaria, measles and respiratory tract infections.

3.15.14 Road and Transport Infrastructure

The road and transport infrastructure in the area is poorly developed. The Mwinilunga - Solwezi T-5 main trunk road links Solwezi District to the Copperbelt and other parts of the North Western Province. This important artery is tarred and is generally in fair condition but also has some sections where major repairs are required. The T-5 is a 541 km long bitumen road running from Kitwe to Mwinilunga. The rainy season adversely impacts the road, extending pot-holed areas and creating new ones. The future state of the road will depend upon the Ministry of Transport policy on road repair for the area. In the project area all roads except for T-5 main road are secondary unsealed roads.

The Malundwe and Chimiwungo sites can only be accessed by 4WD-vehicles during the wet season, from November to April. A detailed track plan is shown on the Topographic Map Figure 3-4. Exploration companies have constructed timber bridges across the Lumwana East River and Chimiwungo Stream, at 3 locations. The bridge positions are also indicated on Figure 3-4.

Road transport in the area is fairly irregular. This makes movement between places difficult. Light trucks and minibuses are an important means of transportation for people and goods. Bicycles are also an important mode of transport and carry farming produce destined for market. Recently, long distance buses from Lusaka and the Copperbelt have become an important transport feature for the district.

In June 2001 ECV conducted a traffic survey on the T-5 trunk road approximately 1.5 kilometres east of the bridge over the Lumwana East River. The site of this traffic survey is shown on Figure 3-18 and the survey data is presented in Appendix 9-N. Traffic survey data indicates that pedestrians represent the dominant form of traffic along the Solwezi - Mwinilunga road. An average frequency of 42 pedestrians per hour was counted. Most of the pedestrian traffic occurred between Monday and Friday (an average of 554 people/day) with a reduced amount of pedestrians observed on Saturday. Sunday's observations indicated a return to average pedestrian counts and reflect the movement of local people to and from religious meetings. The highest pedestrian traffic densities occurred in the early morning (06:00 - 08:00hrs), during lunchtime (12:00 - 14:00 hrs) and in the late afternoon (16:00 - 17:00hrs), conforming to the working habits of the local population.

Bicycles are the next most common means of transport with an average of 104 being observed per day travelling in both directions. Bicycles are used throughout the day with a dip in usage at lunchtime between 12:00 and 14:00hrs.

Motorised transport is not common in the area with an average of 2.35 vehicles per hour in both directions recorded. The most common vehicles observed were 4WD vehicles passing the traffic survey point an average of 21 times a day. The pattern of vehicle density was heaviest in the morning between 07:00 and 09:00hrs and in the afternoon between 15:00hrs and 17:00hrs. This pattern of 4WD vehicle density probably represents the movement of Equinox Copper Ventures personnel travelling to and from the project area.

Only one car was observed during the traffic survey. This indicates that the roads in the area are generally not suitable for cars and also that the assets of the local area did not extend to include personal motor vehicles. Trucks, coaches and mini buses are also quite rare with average traffic densities of 2-3/day.

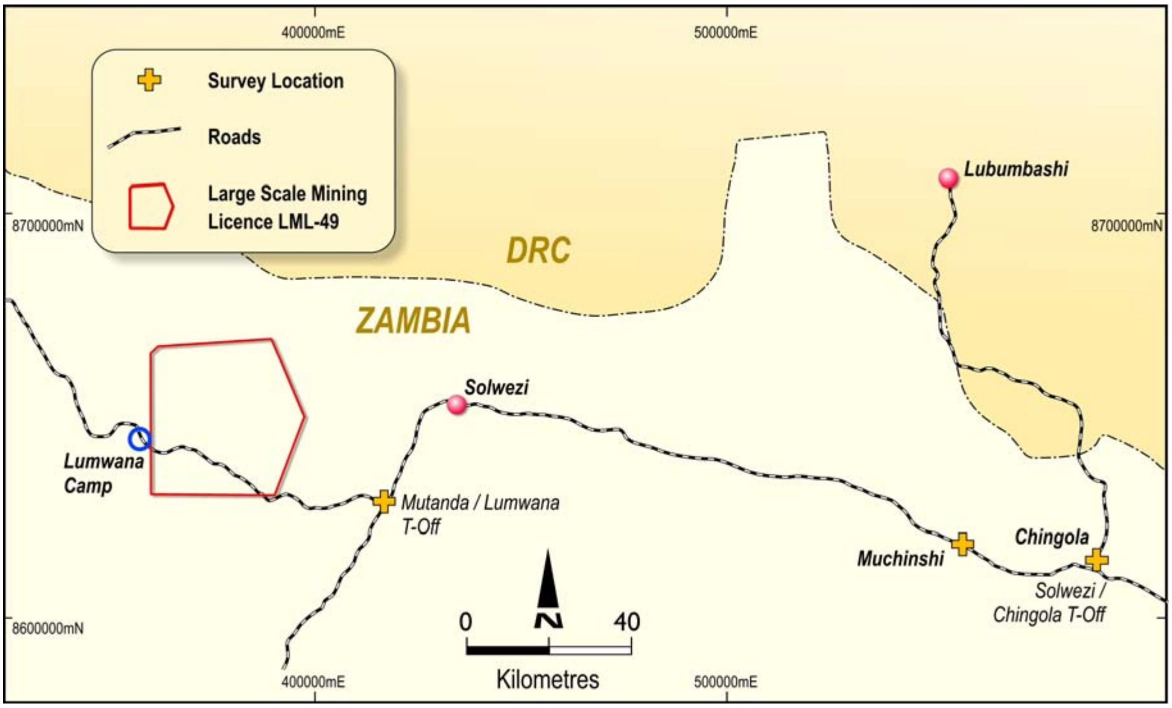
Aircraft traffic in the area is rare. There is an airstrip in the northern part of Chief Mukumbi's area that is used by the Flying Doctor Service. Recently, the number of landings has decreased significantly but this is likely to change in the near future when the government takes over this service.

A more regional traffic survey was conducted in September 2002 by ECV at the following three locations:

Mutanda/Lumwana Turnoff	(UTM E 417100, N 8629915)
Muchinshi Village	(UTM E 557335, N 8619350)
Chingola/Solwezi Turnoff	(UTM E 590055, N 8615237)

The locations of these road traffic survey sites are shown in Figure 3-19.

Figure 3-19: Regional Road Traffic Survey Sites (ECV Sept 2002)



Results of this regional traffic survey are presented in Appendix R and summarised in Table 3-45.

Results of the 2002 road traffic survey indicate that there is more motorised traffic at the Chingola/Solwezi turnoff. Road traffic generally reduces with distance from Chingola. This reflects the industrial and urban nature of the Copperbelt. There are more pedestrians and cyclists in the more rural areas such as Muchinshi and Mutanda.

Since this survey was completed a new copper mine, the First Quantum owned Kansanshi Mine has begun operation near Solwezi, this will have had an impact on the regional traffic, particularly at the two locations east of Solwezi.

Table 3-45: Results of the Regional Road Traffic Survey (September 2002)

Mean Movements	Pedestrian	Bicycle	Motor cycle	Car	4WD	Mini Bus	Truck	Coach	Tractor
Chingola - Solwezi T Junction									
Mean number per day (towards Lumwana)	19	7	0	12	72	11	40	3	0
Mean number per day (away from Lumwana)	15	7	0	13	68	11	33	2	0
Muchinshi Village									
Mean number per day (towards Lumwana)	210	131	0	9	29	7	18	3	0
Mean number per day (away from Lumwana)	221	102	0	8	32	8	15	2	0
Mutanda Junction									
Mean number per day (towards Lumwana)	168	62	2	5	20	5	9	2	1
Mean number per day (away from Lumwana)	228	80	2	7	28	10	15	3	2

3.15.15 Water Supply and Waste Disposal

Wells and streams provide potable water for the communities in the area. Sanitation is by way of pit latrines. Domestic wells have been sunk with the assistance of the Water Affairs Department and organisations such as the International Fund for Agricultural Development (IFAD).

3.15.16 Institutions

Apart from government institutions in the area, there is the traditional structure, the Church, political parties and the local courts. The advent of plural politics in the country since 1991 has encouraged the local people to participate in various political activities. During the 2001 tripartite elections all parties were represented. The main political parties are United Party for National Development (UPND) and the Movement for Multiparty Democracy (MMD). Chief Mukumbi's area falls under the Solwezi West Constituency, which has 2 Wards represented by UPND Councillors.

Welfare institutions include two women's clubs, namely the Lusalwalesa Women's Club and Ukwasho Women's Club. These are mainly involved in the development of traditional female skills such as sewing and knitting. Products are sold for cash or bartered for maize.

Other institutions that have been active in the area include the International Fund for Agricultural Development (IFAD) and the Zambia Social Investment Fund (ZAMSIF). These have been involved in several projects including the construction and extension of school infrastructure in the region. The Department of Water Affairs has been responsible for sinking wells and boreholes in the district.

3.15.17 Non-Governmental Organisations (NGOs) Activities

There are many non-governmental organisations operating in the Solwezi distric. Two of the organisations and current projects include the following:

World Vision International (WVI Zambia)

World Vision, USA, supports the Musele Area Development Programme (ADP) located in Solwezi District. The programme has some 45,000 beneficiaries. The goal of the Musele ADP is improved spiritual and economic life for all community members of Musele by 2008. Musele ADP began operating in 1998 as a sponsorship development programme and currently sponsors 4, 000 children. Activities of the ADP include:

- Financial support of sponsored children in the areas of health, education and general welfare;
- Construction/rehabilitation of school and health infrastructure;
- Food security;
- Christian witness, gender and advocacy;
- Income generating activities; and
- Capacity building.

In carrying out these activities WVI is committed to augmenting efforts of Government and other partners in trying to ameliorate the socio-economic and spiritual depravation facing the people of Solwezi and other parts of Zambia.

Development Aid from People to People (DAPP)

DAPP has been active in Solwezi District through their programme Child Aid Solwezi. DAPP Child Aid Solwezi headquarters is situated in the Mumena Centre approximately 60 km from Solwezi town. The project covers an area of 25 km radius from Mumena. In this project 3000 families have been organised in a family programme which promotes/sponsors a number of activities including new methods of farming, the benefits of permanent dwellings, sinking wells for clean drinking water, VIP latrines, under-5 clinics for immunisation and weight control and other health campaigns in the area.

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4. PROJECT DESCRIPTION

4.1 Project Overview

It is proposed to develop an open-cut copper mine in the North-Western Province of Zambia. The project is located on a green field site approximately 300 km by road from the Copperbelt city of Kitwe and 65 km (direct line) west of the provincial centre Solwezi. The border with the Democratic Republic of Congo is approximately 45 km north of Lumwana and the Angolan border lies approximately 200 km to the west.

Key infrastructure components (as shown on Figure 4-1) to be developed for the project includes:

- Development of a number of large open pits;
- Construction of a 330 kV power line from Solwezi to the Project site and reticulation of that power to key activity areas ;
- Construction of a number of fresh water dams;
- Construction of a copper concentrator processing facility and associated infrastructure;
- Construction of various access roads to support the project;
- Construction of a tailings storage facility;
- Construction of a residential estate adjacent to the project; and
- Construction of infrastructure to support the above operations (maintenance, processing, bulk explosives and administration facilities).

It is intended to mine the reserve in two pit areas.

- Area 1 is the Malundwe reserve and will be mined and processed during the first five and a half years of the project with the pit being broken into ten (10) stages; and
- Area 2, the Chimiwungo resource will be mined and processed from year five and a half to 18 with the pits being broken into eight (8) stages.

Area 1 will involve the mining and processing of approximately 105 Million tonnes (Mt) of ore over a five year period. Two pits will be developed at this time. Area 2 will be developed during the next 13 years and involve the mining and processing of approximately 260 Mt of ore from three pits at the Chimiwungo deposit. Three distinct waste rock dumps will be constructed over the life of the project. One adjacent to the Malundwe pits and two dumps created from the Chimiwungo pits.

4.2 Ore Reserve

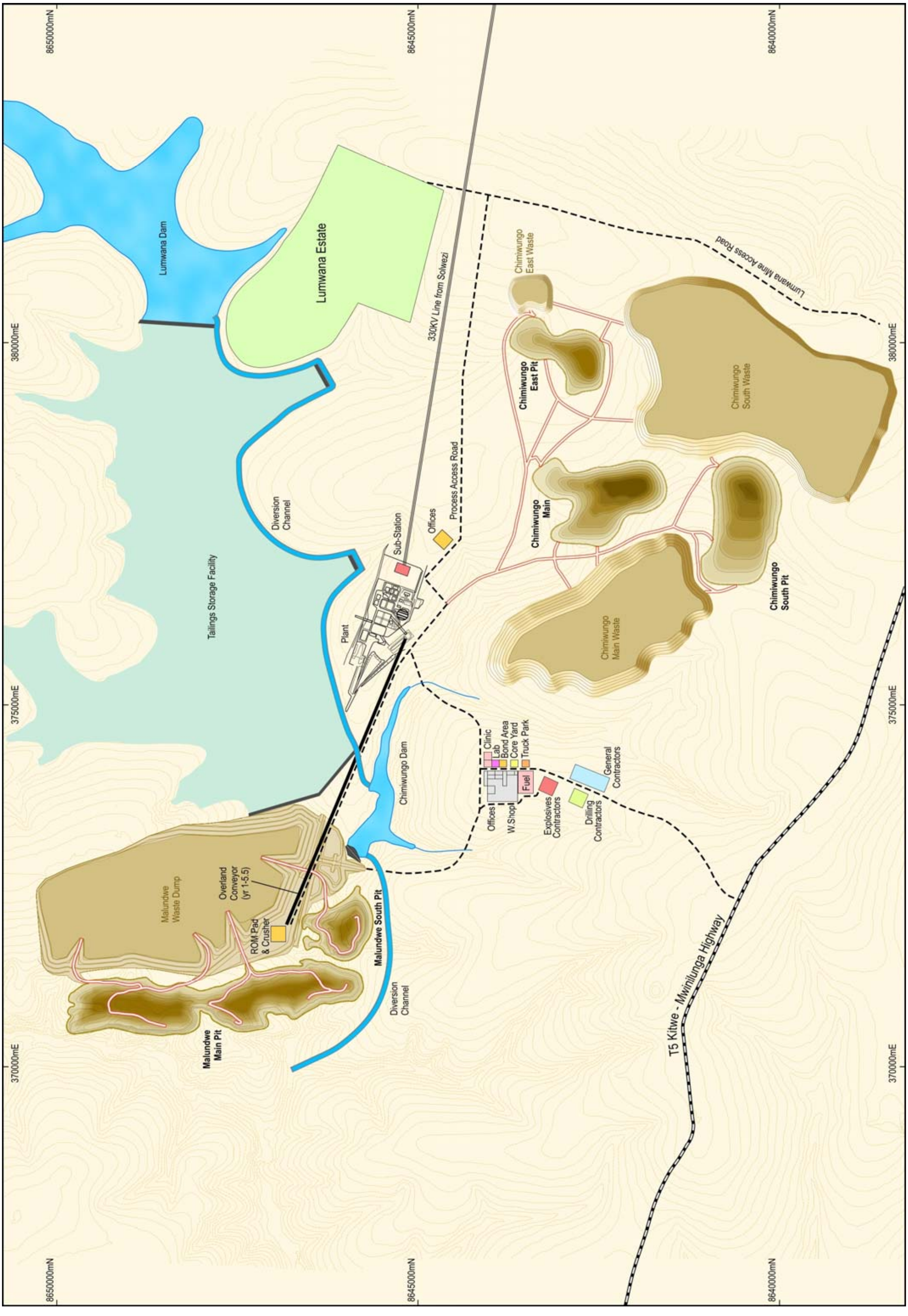
The reserve is described in detail in Section 3.5.3. In summary, the total known reserve is shown in Table 4.1

Table 4-1: Total (Malundwe and Chimiwungo) Copper Reserve (at 0.20% Cu Cut-Off) - Based on a 12.5mx12.5mx8m reserve block model

Class	Tonnes (Mt)	Cu (%)
Malundwe	114.1	0.95
Chimiwungo	249.8	0.68
Total	363.9	0.76

Uranium is also present in discrete zones within the Malundwe and Chimiwungo resources. High-grade uranium bearing ore will be stockpiled and encapsulated within specific areas of the Malundwe and Chimiwungo waste rock dumps.

Figure 4-1: Lumwana Mine Layout



A decision may be made later in the life of the project to process this ore, hence there is a need to ensure it is economically viable to retrieve this ore. Table 4.2 shows the uranium resource.

Table 4-2: Lumwana Uranium In-Pit Resource at 700 ppm U Cut-off

Class	Million Tonnes (Mt)	U ppm
Malundwe	1.1	3,043.8
Chimiwungo	0.3	1034.9
Total Resource	1.4	2596.7

4.3 Project Layout

The main project components and infrastructure comprise the following:

- Malundwe - main pit;
- Malundwe - east pit;
- Chimiwungo – main pit;
- Chimiwungo – south pit;
- Chimiwungo – east pit;
- Run of Mine (ROM) stockpile area;
- ROM Crusher;
- Plant area;
- Conveyor systems for ore handling;
- Administration areas;
- Maintenance workshop area;
- Light industrial area for contractors;
- Electrical infrastructure;
- Bulk explosives facility;
- Explosives magazine facility;
- Fuel facility;
- Water treatment plants;
- Sewerage treatment facilities;
- Water storage facilities;
- Tailings storage facility; and
- Housing estate

4.4 Mining Methods

The Malundwe and Chimiwungo deposits will be mined by conventional open pit mining methods using both bulk and selective mining methods. The waste will be mined on 8m benches with an option to be increased to 16m if operating parameters allow and 4m 'selective' mining in the ore zones.

This will be carried out using face shovels in the waste areas and excavators with the assistance of front end loaders and dozers to mine the ore zones. Each machine has the capacity to mine about 26 Mt per year and the mobility to allow it to move from face to face if required.

These trucks will utilise reticulated power for assistance throughout a proportion of their haul cycle. This will significantly reduce diesel consumption and NOX and SOX emissions whilst largely utilising hydro power from the ZESCO hydro generated power grid, a renewable resource.

Ore and waste will be hauled using (approximately) 230 tonne electric drive AC trucks suitable to be fitted with a pantograph so that it can be used in the trolley-assist application.

To achieve the above, significant amounts of electrical infrastructure will require installation within and around the open pit mining operation. This will include:

- High voltage catenary structures in pit and waste dumps;
- High Voltage trailing cables and associated infrastructure to power loading units;
- Power reticulation for pit lighting;
- Power reticulation for pit dewatering.

4.5 Mine Plan

It is intended to mine the reserve in two pit areas. (See Figures 4-2 and 4-3)

- Area 1 is the Malundwe reserve and will be mined during the first and half years of the project with the pit being broken into ten (10) stages; and
- Area 2, the Chimiwungo resource will be mined from year five and half to 18 with the pits being broken into eight (8) stages.

Exploration will continue within LML-49 as well as other exploration ground outside the License Area that ECV has title to. This may further increase the mine life or change the mining plan over time.

The ultimate mined depth and size of the three pits once mining is completed is shown in Table 4-3.

Table 4-3: Size and Area of Malundwe and Chimiwungo Pits

Pit	Crest and Toe RL's in pits	Average Maximum Depth (m)	Length (m)	Width (m)	Area (ha)
Malundwe – main (nth)	1340-1168	172	1,740	770	130
Malundwe – main (sth)	1318-1160	158	2,270	680	148
Malundwe – east	1278-1120	158	815	800	70
Chimiwungo - main	1364-1116	248	1,810	1,090	139
Chimiwungo - east	1380-1210	170	1,300	920	77
Chimiwungo - south	1370-1088	282	935	1,800	148

4.6 Ore Production Schedule

A life of mine mining schedule has been developed on the basis of the reserve in Table 4-1 with the intent of providing higher grade copper ore to the plant from year 1. Table 4-4 summarises the mining schedule showing the tonnage and average run of mine grade for the copper ore.

4.7 Mining Operations

The Malundwe and Chimiwungo deposits will be mined using open pit mining methods. The yearly ore production is approximately 20 Mt of ore per year at an average strip ratio of 3.5:1 waste:ore ratios (on a tonnage basis). The average yearly material movement peaks at 155 Mt in Year 3 but maintains a steady state of approximately 90 Mt through to year 13 when the total will diminish to the end of mine life in Year 18. The operation will require large scale mining equipment and be supported by well trained personnel in the Operation and maintenance areas.

Figure 4-2: Mine Plan Area 1 - Malundwe

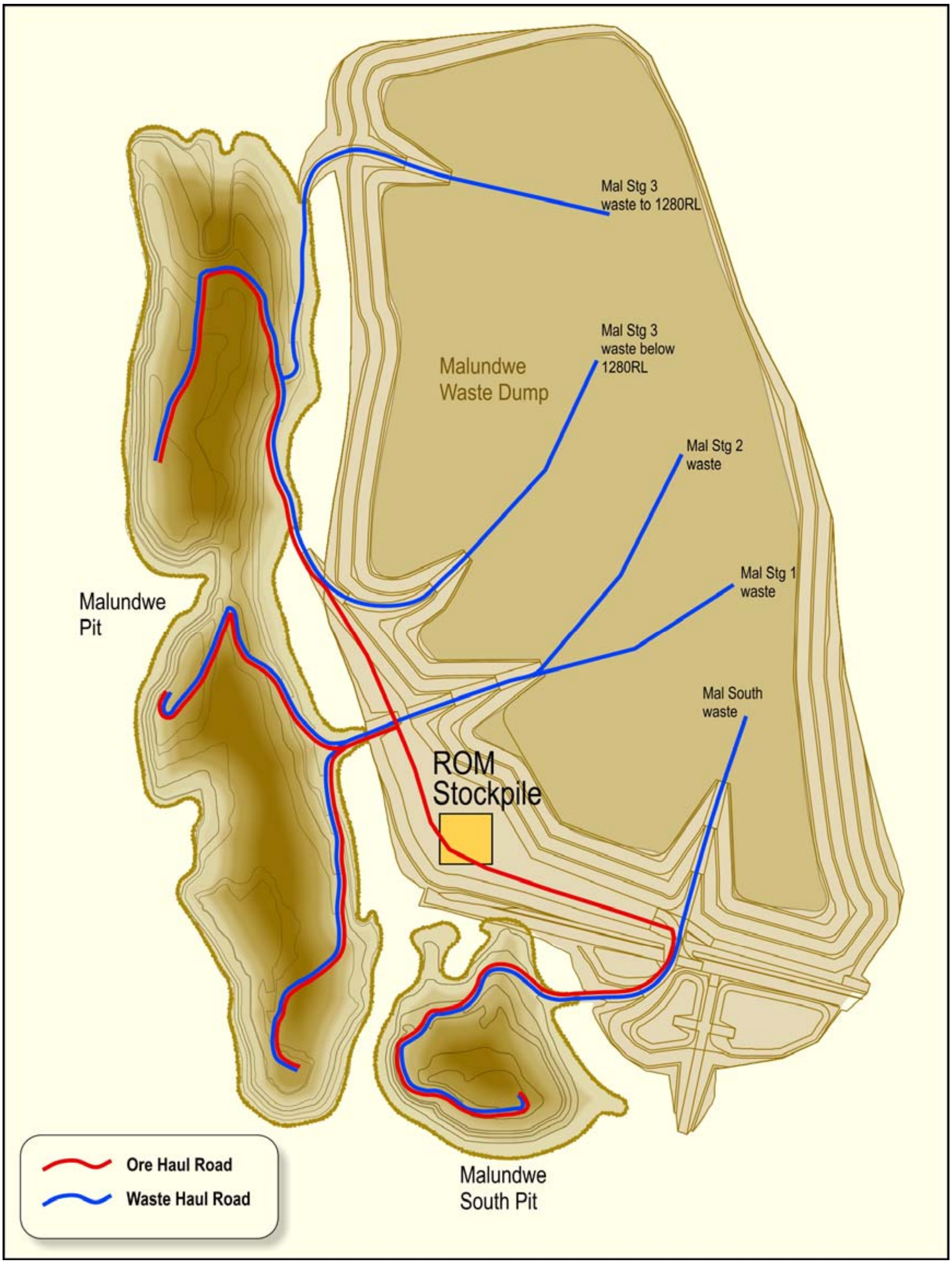
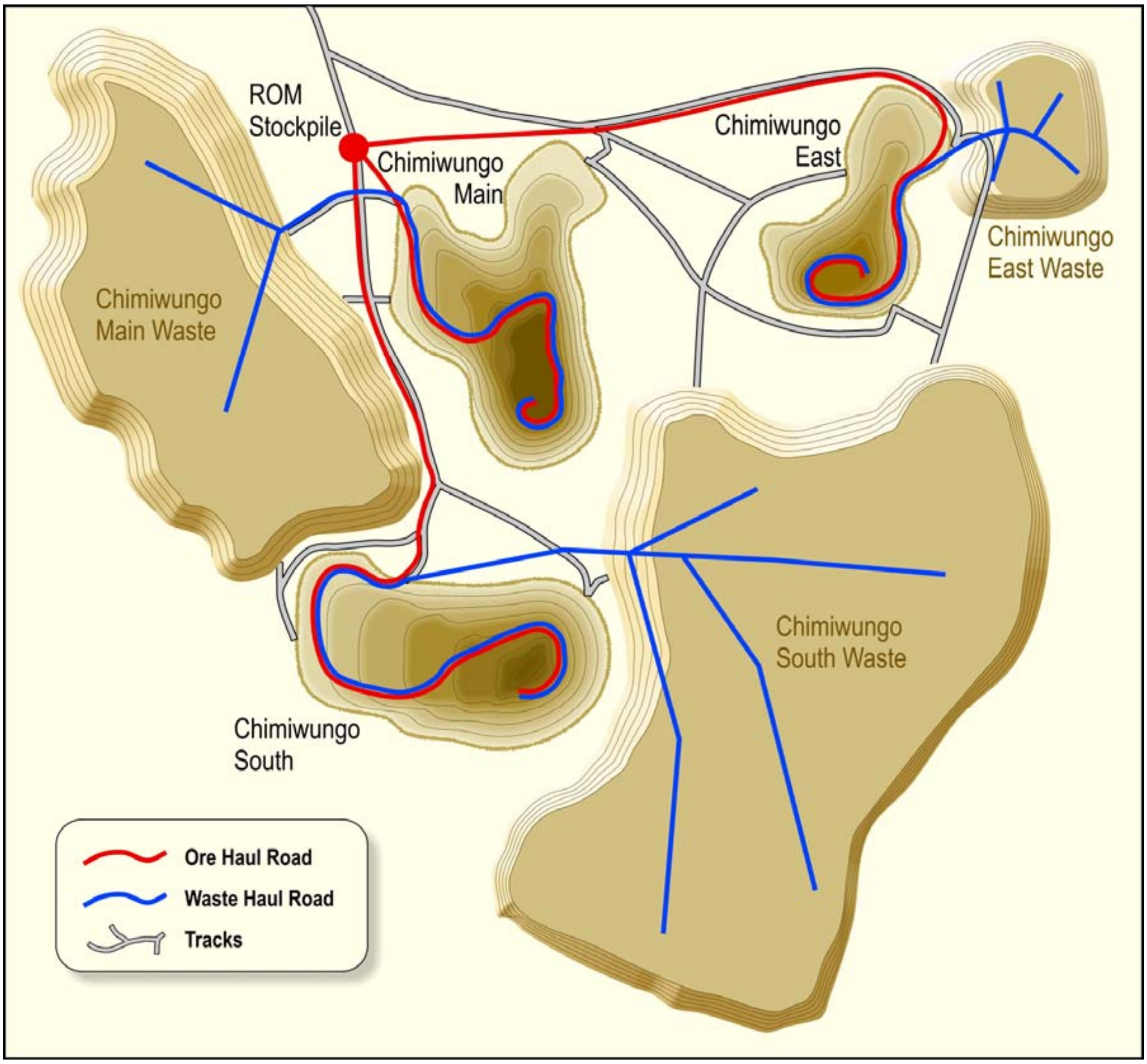


Figure 4-3: Mine Plan Area 2 – Chimiwungo



4.7.1 Ore and Waste Mining

The ore will in general be mined using 8m benches in the waste and 4m in the ore zones dependent upon finalisation of studies to ensure minimal dilution of the ore body. Ore will be mined from the pit and hauled to the RoM pad near the crest of the Malundwe main pit southern ramp and built within the Malundwe waste dump and at the crest of the Chimiwungo pit at the pit exit. Ore will be 'direct tipped' by the 230 t trucks into a gyratory crusher or stockpiled on the ROM pad for later rehabdling with a front end loader.

From the Gyratory crusher the ore will be conveyed by an approximately 2.0m wide belt conveyor up to 4.5km from the RoM pad to the Fine ore stockpile at the Processing plant.

The Reverse Circulation (RC) Grade control holes will also be drilled at a spacing of 24m and backfilled to 8m to ensure the ore body is defined on and below the working bench and to ascertain additional Grade control requirements on subsequent benches. Sampling will be based on 2m composites for both RC and blast holes.

In addition to RC grade control and to ensure minimal dilution of the ore body, grade control will be supplemented by sampling of blast holes. Visual control, mapping and drilling data will also be used to determine the hanging wall and footwall contacts. The hanging wall and footwall contacts will be cleaned by dozers where necessary to minimise dilution and losses.

Initial mining activity will commence on site at 6 months prior to plant commissioning to provide exposure and stockpiling of the sulphide ore and to provide suitable waste material for the building of the RoM pad, conveyor base, various storage facilities and other construction activities.

Table 4-4: Mine Production Schedule

YEAR	WASTE	COPPER ORE		WASTE to ORE RATIO
	Tonnes (Mt)	Tonnes Mt	Cu %	
Year -1	19.1	1.4	0.840	13.2
Year 1	100.3	17.6	1.211	5.7
Year 2	131.0	20.0	0.997	6.5
Year 3	135.0	20.0	0.992	6.7
Year 4	110.5	20.0	0.813	5.5
Year 5	78.5	20.0	0.838	3.9
Year 6	75.9	20.0	0.769	3.8
Year 7	69.5	20.0	0.759	3.7
Year 8	68.5	20.0	0.735	3.4
Year 9	69.5	20.0	0.684	3.5
Year 10	68.9	20.0	0.615	3.4
Year 11	69.1	20.1	0.586	3.4
Year 12	68.1	20.1	0.638	3.4
Year 13	46.2	20.1	0.671	2.3
Year 14	31.6	20.0	0.651	1.6
Year 15	19.2	20.0	0.645	1.0
Year 16	13.6	20.0	0.736	0.7
Year 17	12.4	20.0	0.841	0.6
Year 18	2.3	4.4	0.897	0.5
Total	**1,180.9**	**344.3**	**0.774**	**3.5**

4.7.2 Blasting

Blast holes will predominantly be 210mm diameter holes in a 6.9m x 6.0m in the waste and 7.5m x 6.0m in the ore at 0.65kg/m^3 and 0.56kg.m^3 powder factors (pf) and at a depth of 8m. Once initial drilling and assessment of rock hardness, fragmentation and type has been carried out there is a potential to utilise 16m depth blasting.

Blasting will be undertaken using ANFO explosives in dry areas and Emulsion in wet areas, electric surface and 'down the hole' detonators will also be utilised to initiate the blast. In addition 'stemming' material will be used to ensure good fragmentation of the rock and to help reduce 'air blast' noise.

All blasting will be undertaken using a remote means of initiation by trained and certified competent personnel.

4.7.3 Dewatering

To ensure safe and effective mining can take place, dewatering must be carried out both within and outside the pit limits. Total estimated dewatering rates for combined groundwater and rainfall inflows have been estimated and are shown in Table 4-5. The rainfall inflows are based on a 24 hour, 1 in 20 year event and a pump out time of up to a week.

Table 4-5: Total Estimated Dewatering Rates

Pit	Catchment Area (ha)	Rainfall Volume (ML)	Rainfall Pumping Rate (ML/d)	Max Groundwater Inflow (ML/d)	Combined Max Pumping Rate (ML/d)
Malundwe Main	215	254.5	33.4	14.2	47.6
Malundwe East	57	62.1	8.9	11.7	20.6
Chimiwungo South	150	163.5	23.3	15.0	38.3
Chimiwungo Main	140	152.6	21.8	10.0	31.8
Chimiwungo East	77	83.9	12.0	5.0	17.0

Dewatering is based on the use of dewatering bores ahead of mining, located where suitable high yielding fracture zones are identified.

Dewatering water will be pumped to dams for use as dust suppression within the mine area. Excess water will be analysed and provided quality meets statutory requirements, discharged to the East Lumwana River.

4.8 Primary Crushing

In general the Unconfined Compressive Strength (UCS) test work results showed that the structure of the ores are relatively weak at around 20 - 50 Mpa and on the low end of competency. This indicates that the ore is very amenable to crushing and SAG milling.

Comparatively the waste exhibits a considerably harder structure 120 – 170 Mpa reflecting the gneiss, quartz and feldspar components.

Whilst the UCS indices for the ore zones are relatively low, the possibility of dilution from the harder waste zones is highly likely and such the harder UCS indices were considered during the design of the crushing circuit.

The final layout for the primary crushing circuit involves a 60” x 89” gyratory crusher located within a concrete crushing chamber set back from the edge of the ROM pad. This arrangement does not require any retaining walls, however, due to the set back from the base of the ROM pad the discharge conveyor is installed inside a tunnel. The discharge rate from the crusher is controlled using a variable speed apron feeder allowing the crusher discharge conveyor to discharge directly onto the 4.5km overland conveyor. Maintenance of the crusher ancillaries is through an open vault that runs from the ROM pad level down to the apron feeder level.

The crusher has the benefits of two truck tipping with the tip point well away from the edge of the ROM pad, good access for maintenance via a maintenance bay and hoist at the front of the crusher structure, robust structure with no design or operational risk and minimal capital cost in comparison with the other structures investigated.

Ore at a maximum lump size of 1.5m, will be trucked using the 230t dump trucks to the ROM stockpile/primary crusher area located on the waste dump within close proximity to the operating mine.

The ore is direct dumped into a 500t capacity concrete bunker which direct feeds the gyratory crusher. The gyratory crusher has a capacity of 4,000 tph at a product size of 200mm. Design availability of the crushing circuit is 75%.

During the first five years of mining (Area 1) only the Malundwe pit will be mined with the ROM stockpile and primary crusher located in the south west corner of the waste dump, approximately 4.5 km from the plant site.

At the commencement of mining the Chimiwungo pits, a new crusher will be built on the Chimiwungo waste dump area and once reserves are exhausted at Malundwe, the Malundwe located crusher will be relocated to a second site at Chimiwungo to ensure haul distances from the operating pits are minimised.

4.9 Crushed Ore Transport and Stockpile

A 4.5km, 4,000 tonnes per hour overland conveying system will be utilised to transport crushed ore to the process plant. The overland conveyor belt operates at a speed of 5m/s and due to its length is specified as a steel cord belt. A series of motors and drives will power the conveyor with a total power rating of 2,500kW.

The crushed ore will transfer from the overland conveyor to the stockpile feed conveyor. The stockpile feed conveyor is a 250m long belt which elevated the ore up 40m onto the top of a crushed ore stockpile (COS) within the processing area footprint. 600kW in total is used to power the stockpile feed conveyor through a series of motors and drives. The COS is designed with 16 hours live capacity at 40,000 tonnes. The total COS stockpile capacity is approximately 300,000 tonnes.

4.10 Ore Processing

Ore will be processed using a conventional milling and flotation process with the intent of producing a copper concentrate product for transport and sale to a smelting and refining facility for further processing to copper cathode. This stage of the production process is referred to as the Concentrator.

The Concentrator will be designed to treat either ore type (Malundwe or Chimiwungo) at a rate of 20 Mtpa. With this processing schedule the mine produces an average life-of-mine grade of 0.77% copper, resulting in the production of 450,000 dry tonnes per annum of copper concentrates containing 30.6% copper. To achieve this, the plant is designed to operate for 8,100 hours per year or for 91.6% of the year (life-of-mine average). Copper recovery to concentrate is 96.7%.

Ore concentration will be undertaken in three phases (Figure4-4):

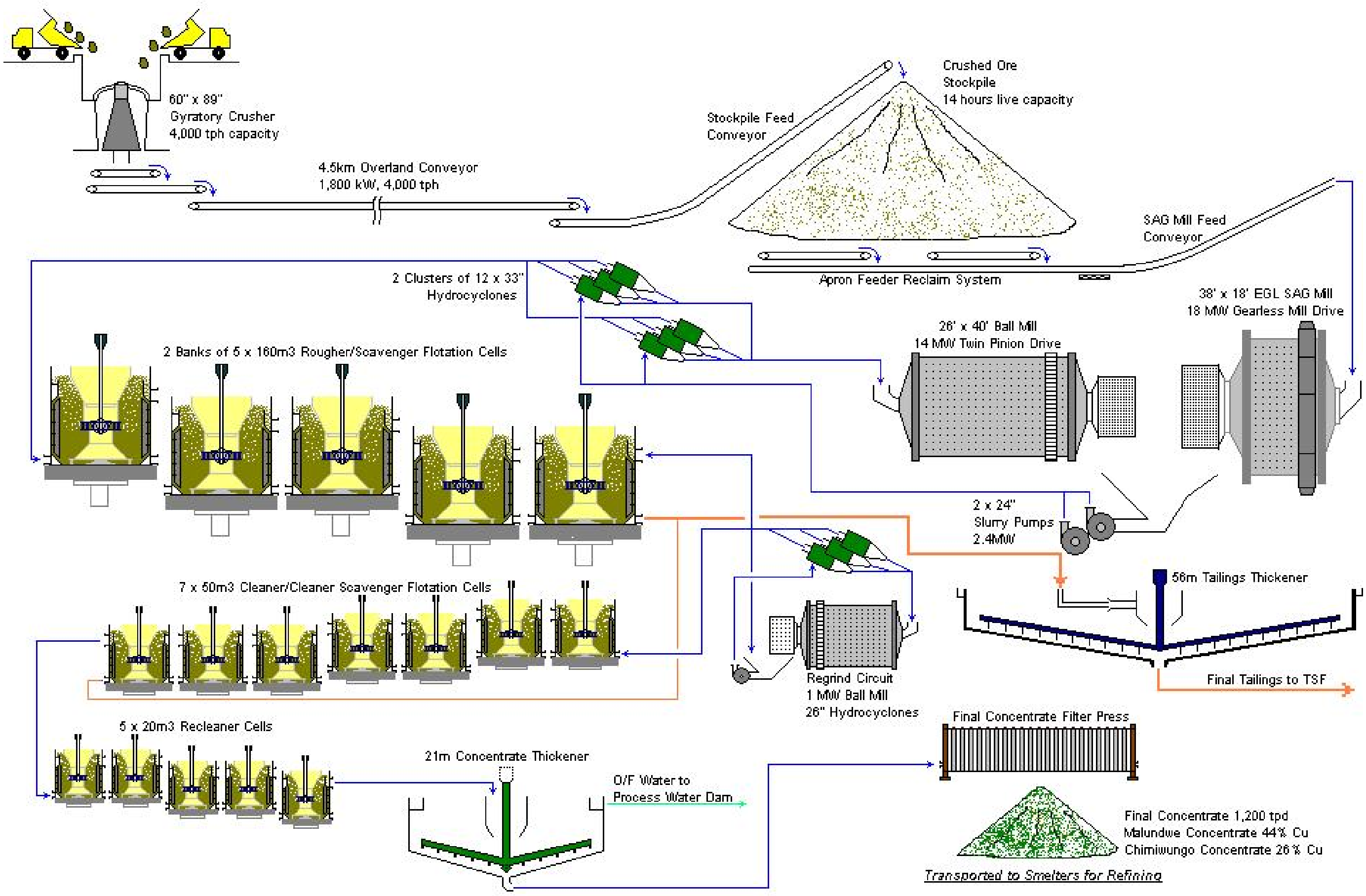
1. Milling
2. Flotation
3. Concentrate dewatering and storage

Crushed ore is extracted from under the COS stockpile by two variable speed reclaim apron feeders (each with a capacity of 2,500 tph) that discharge to a belt conveyor feeding the milling circuit. The design mill feed rate is 2,500 tph equating to 20 million tonnes per annum with a 91.6% availability.

The milling circuit comprises a 38ft x 18ft, 18MW gearless drive Semi-Autogenous Grind (SAG) Mill. The purpose of the SAG mill is to reduce the crushed product from a nominal 200mm top size to a 2mm SAG mill product size (coarse sand). 35mm internal grates inside the mill retain the larger product within the mill until it is small enough to pass through the grates and onto the ball mill. The SAG mill is loaded up to 350 tonnes (12% by volume) with 125mm forged steel balls which assist with the grinding process.

The SAG mill shell is internally lined with approximately 550 tonnes of chrome moly steel liners which are replaced every six (6) months. A modern seven axis liner handler machine is required to help replaced these liners some with an individual weight of 3,500kg.

Figure 4-4: Process Flow Diagram



The product from the SAG mill passes into the sump tank and is pumped by one of two 24/22 mill discharge slurry pumps operating in parallel. Each pump is serviced with a 2,000kW variable speed high voltage motor, which pumps the slurry to a separate set of 12 x 33" hydrocyclones. The fine material at 280 microns flows out the top (overflow) of the hydrocyclone and onto the flotation circuit whilst the larger particles gravitate to the bottom (underflow) of the cyclone and into the ball mill.

The ball mill is a 26ft x 40ft, 14MW twin pinion gear driven ball mill. The ball mill is loaded up to 650 tonnes (28% by volume) with 65mm and 50mm high chrome steel balls which assist with the grinding process.

The ball mill shell is internally lined with approximately 400 tonnes of high chrome steel liners which are replaced every twelve (12) months. A modern seven axis liner handler machine is required to help replaced these liners some with an individual weight of 2,500kg.

The purpose of the ball mill is to further grind the ore to produce a product of around 280 microns in size. The ball mill circuit is designed to operate at 250% recirculating load (6,250 tph). Once the particles have been sufficiently ground to 280 microns they pass through the overflow of the hydrocylones and onto the flotation circuits.

The product from the milling circuit flows directly to the flotation circuit where it enters one of two parallel banks of 5 x 160m^3 capacity rougher/scavenger flotation tank cells with a 1,2,2, configuration. Each cell is 6.5m diameter and 8.0m high and is operated by a 150kW motor.

There is facility within the design to add an additional cell to each train making six cells per bank with a 2,2,2 configuration.

The tailings from the rougher/scavenger cells report to the 56m diameter tailings thickener where the density of the slurry is raised from 35% to 55% solids prior to disposal into the tailings storage facility (TSF). The water recovered from this thickener is recycled back into the milling circuit and reused.

The concentrate from the rougher/scavenger cells which is approximately 5 – 7% of the feed mass and typically 180 microns in size (finer than the initial flotation feed) is pumped into the regrind circuit where a 14ft x 18ft, 1MW single pinion fixed speed regrind mill is used to grind the concentrate particles down to 100 microns (0.1mm). The regrind mill is in closed circuit with its own pumps and hydrocyclone circuit.

The regrind mill is loaded up to 100 tonnes (28% by volume) with 38mm high chrome steel balls which assist with the grinding process.

The ball mill shell is internally lined with approximately 40 tonnes of rubber liners which are replaced every eighteen (18) months. Relining the mill shell will be carried out manually due to the light weight of the individual liners.

This process further helps to liberate the sulphide particles from the gangue minerals to produce a higher grade concentrate. Test work has indicated that a regrind circuit will improve the final concentrate grade by as much as 5% with only a 1% loss in overall copper recovery.

The reground concentrate is subsequently treated in 7 x 50m^3 cleaner and cleaner/scavenger flotation tank cells to upgrade the concentrate prior to the final upgrade treatment in the 5 x 20m^3 recleaner flotation tank cells.

The flotation circuits produce the final concentrate from the recleaner cells and a secondary tails stream that reports from the cleaner/scavenger cells to join the primary tails stream being fed to the 56m diameter tailings thickener.

Finally, copper concentrate flows from the flotation circuit to the dewatering circuit. This consists of a 20m thickener which is used to increase the solids content of the concentrate slurry from 35% to 65% prior to being pumped to one of two 1,000 m^3 stock tanks with a total of 24 hours capacity.

The stock tanks are used as storage prior to the filtration circuit which consists of a single horizontal pressure filter and concentrate storage shed. The pressure filter further increases the solid content to 92%. Filter cake from the filter press drops into the concentrate storage shed below where it is stockpiled with a front end loader with a nominal 4m^3 bucket capacity.

Approximately, 1,200 tonnes of copper concentrate is stockpiled daily prior to transport off site to smelting facilities. The enclosed concentrate storage shed is designed for 7 – 10 days capacity. Additional storage capacity is available on adjacent prepared ground using temporary tarpaulin covers for weather protection.

Although, there is sufficient water capacity available at the Lumwana site, all endeavours have been made to maximise the reuse of water. Approximately 2,500 m^3/hr of water is recovered from the 56m tailings thickener for reuse in the milling circuit. Additionally, 1,200m^3/hr of make up water for the milling circuit is recovered from the decanted water on the tailings storage facility and approximately 1,500m^3/hr of raw water is extracted from the various site water storage dams. The concentrator and tailings storage facility are considered to be under a negative water balance in that additional raw water is required as make up water for the processing of the copper concentrate.

Reagents used in the Concentrator are trucked to the site in bulk with expected site inventories ranging from one (1) to three (3) months depending upon the reagent and the time of the year. Higher inventories will be maintained on-site during the wet season reducing any risks brought on by the rains.

The following reagents are used with their corresponding annual consumption rates:

- 125mm forged steel grinding balls 7,000 tpa
- 65/50mm high chrome grinding balls 5,500 tpa
- 38mm high chrome grinding media 550 tpa
- IF55 Frother, equivalent 400 tpa
- PAX Collector, equivalent 700 tpa
- Magnafloc 155 Flocculant, equivalent 100 tpa

Grinding media is expected to be supplied in bulk 20 tonnes lots, typically in half height sea containers. These will be dumped into concrete holding bunkers where they will be recovered using a front end loader and loaded into a metering system which will feed the media into the respective grinding mill.

Frother is delivered in liquid form in bulky bins and is pumped to an on site storage tank from where it is metered to the flotation circuit as required.

Collector is delivered in powder form and is made up into a solution prior to pumping to storage. From storage, the collector solution is metered to the flotation circuit as required.

Flocculant is delivered in powder form and, like the collector, is made up using with site facilities and pumped to storage. From storage the solution is metered to the tailings and concentrate thickeners as required.

Economic opportunities exist to consider the construction of additional infrastructure to enable the production of copper cathode on site. A roast-leach-electowin (RLE) process has been previously assessed as part of the original BFS. Should this be deemed technically and economically feasible in the future, application will be made for the required approvals.

Average annual production is shown in Table 4-6.

Table 4-6: Average Annual Production

	Concentrate Produced (tpa)	% Copper Recovery	Copper Grade (%)	Equivalent Copper Metal Produced (tpa)
Year 1-5 Malundwe	450,000	95.8	44%	190,000
Year 6-18 Chimiwungo	520,000	97.3	26%	135,000

4.11 Concentrate Transport

ECV is presently seeking proposals and quotation for the transportation of the copper-enriched copper concentrate from Lumwana to the Copperbelt. The expectation is that these concentrates will be transported by road in semi-trailers with an expected payload of approximately 35 tonnes and a gross vehicle mass compliant with Zambian government regulations. With an average of 540,000 wet metric tonnes of concentrate per year, the vehicle movements will be approximately 16,500 per annum each way or 45 per day each way. That is a total of 90 vehicle movements per day.

The concentrate trucking will likely be undertaken by a contract organisation involving a 24 hours per day, 7 day week operation. This will result in on average 4 vehicle movements per hour.

Concentrates are expected to be mostly treated on the Copperbelt. However some concentrates may be transported to Palabora (South Africa) and Tsumeb (Namibia). Concentrate quantities and thus vehicle movements are still to be defined but this is expected to be a relatively small percentage, in the order of 25-30% of total concentrate. Road transport is still the expected method of transport.

4.12 Waste Rock

Waste rock material from the Project will total around 1.2 billion tonnes over the life of the operation.

All waste rock will be placed in dedicated areas on one of three waste rock dumps - Malundwe, Chimiwungo West and Chimiwungo South or used as earthwork construction materials during the construction phase of the project. Studies undertaken during the BFS by Campbell (2002b) indicate that the sulphidic waste to be produced during mining operations should not be a source of acid rock drainage.

The combined surface area of the waste dumps is 1,950 hectares.

4.12.1 Waste Rock Characterisation

As a component of the BFS, Graeme Campbell & Associates were commissioned to investigate the ARD potential of mine waste rock. ARD could adversely impact groundwater and surface water quality in the vicinity of the mine. Geochemical characterisation was performed on three representative samples of sulphidic internal waste from the Malundwe deposit. The key findings of this report (2002b) are discussed below.

Acid-base-analysis, salinity and Net-Acid-Generation (NAG) test results indicated the sulphidic internal waste samples to:

- Be mildly alkaline (pH between 8 and 9);
- Have low soluble salts content (electrical conductivity <0.1mS/cm);
- Contain only trace amounts of pyrite and other sulphide minerals (sulphide content <0.3%);
- Have a low Acid-Neutralisation Capacity (ANC) of 3.5 - 5.2 kg H_2SO_4/tonne;
- Have a Net Acid Producing Potential (NAPP) values ranged from -1.6 to 4.2 kg H_2SO_4/tonne; and
- Have NAG pH values ranged between 5.5 and 6.0 with NAG values of between 0.5 and 0.6 kg H_2SO_4/tonne.

Despite the absence of carbonates in the sulphidic waste, pH values under the strongly oxidising conditions in the NAG Tests remained above 5. This was due to the buffering capacity through hydrolysis/dissolution of the mafic-silicates present. The anticipated Sulphide Oxidation Rate (SOR) for the weathering of ‘trace sulphides’ is 1-2 kg H_2SO_4/tonne/annum. Hydrolysis/dissolution of the mafic-silicates (near pH 7) should match the predicted slow rates of sulphide oxidation. The test work results indicate the waste rock samples to be Non-Acid Forming (NAF).

Multi-element geochemical analyses performed on two of the sulphidic internal waste samples indicate that the samples are characterised by low concentrations of environmentally significant elements. Elements that exceeded the average - crustal abundance were Copper - 0.2%, Cobalt - 0.007% and Uranium 0.0008%. These element concentrations would be expected close to a copper deposit.

Based on the test work results Campbell (2002b) concluded that the sulphidic waste produced from the Malundwe deposit should not be a source of ARD.

Geologically, the sulphidic internal waste should have the highest concentration of sulphides. On this basis, other lithological waste to be mined from the Malundwe pit should not be a source of ARD.

Similarly work undertaken to characterise the waste rock from Chimiwungo, indicates that the waste rock is of a similar nature with similar analytes and therefore it would not expected to be a source of ARD. Confirmatory studies will be undertaken prior to mining the Chimiwungo resource.

4.13 Tailings

It is estimated that approximately 370 Mt of tailings will be generated during the life of the project.

Tailings will be disposed sub-aerially into the tailings storage facility (TSF) constructed in the valley of the Lumwana East River. The river will be diverted around the TSF to ensure impacts are minimised.

4.13.1 TSF Deposition Options

As part of the BFS, options that were considered in respect of tailings deposition, included:

- Sub-aqueous deposition in a TSF in the Lumwana East River Valley, co-disposed with water; and
- In-pit disposal in pits once resource is exhausted.

In evaluating the project, it has been determined the least environmental impact will occur with a single TSF and a separate water storage facility upstream of the TSF.

4.13.2 Tailings Characterisation

As a component of the BFS, geochemical and metallurgical investigations were undertaken on tailings slurry from the Malundwe ore. The key difference between Malundwe and Chimiwungo ore is that there is less sulphur in Chimiwungo and lower levels of uranium, in all other analytes, the ore bodies are similar. Despite the test work being undertaken on Malundwe ore only, the ore types are considered to be similar.

The results from the BFS investigations coordinated by Golder (Campbell, 2002a) and reviewed by Knight Piésold (2005) conclude the following:

- The tailings solid sample is classified as non-acid forming (NAF) and reflects negligible sulphides (sulphide-S content less than 0.1%) in a gangue of micaceous-minerals; and
- The tailings-slurry-water sample was neutral to alkaline, and of potable-salinity, with concentrations of most minor elements below, or close to, the respective detection limits (that ranged up to 10 µg/L). The exception was uranium with a concentration of approximately 100-200 µg/L.

  NB: Baseline surface water sampling detected uranium in surface water at levels of up to 700 µg/L, (mean of approximately 90 µg/L)

Therefore it is determined that:

- The tailings will be benign (acid drainage will likely not be a concern); and
- Seepage from the tailings facility will not be a concern.

4.13.3 Tailing Storage Facility (TSF) – Design and Operation

The factors considered in the process for designing the TSF include:

- Design parameters and assumptions;
- Site selection;

- Site investigations;
- Structural geology;
- Seismicity;
- Hydrogeology;
- Flood analyses; and
- Seepage analyses.

The TSF will be constructed in the Lumwana East River Valley, north of the proposed plant site. The river will be diverted as discussed in Section 4.15 and the TSF embankments will be constructed across the valley of the Lumwana East River. This dam is located 1.3 km upstream from the eastern edge of the Malundwe SE pit in a relatively narrow section of the Lumwana East River Valley. The western embankment will be ultimately buttressed by the Malundwe waste rock dump. Freeboard, spillway and channels are designed around a 1 in a 100 year rainfall event.

Tailings will be discharged into the facility by sub-aerial deposition methods, using a combination of spigots at regular intervals, and single point discharges. The active tailings beach will be regularly rotated around the facility so as to maximise tailings density and evaporation of water.

The TSF is designed to operate for the life of the project, 18 years with a total volume of 370 Mt and a surface area of around 2,000 hectares.

4.14 General Waste

Typical general waste to be generated by the Project will include iron, steel, wooden materials, rubber, plastic, office waste, food scraps, rags, glass, metal drums, oily waste and medical waste.

No polychlorinated biphenyl (PCB) containing products will be used on site and there will be no PCB containing waste produced as a result.

Medical waste (such as used first aid material) or waste containing hydrocarbons or other chemicals will be treated as hazardous and specific measures will be undertaken to ensure no contamination occurs as a result of management of the waste.

4.15 Site Water Management

The management of surface water and supply of water for ore processing is a critical aspect of operations. Site water management studies have been completed by Knight Piésold (2005) to:

- Develop a water balance model to understand the water storage characteristics of the various impoundments; and
- Hydrological modelling to examine the management of water through diversion structures in the case of storm events.

The water balance model incorporates the following components:

- Plant and ore processing;
- Tailings storage facility (TSF);
- Waste dumps;
- Open pits and groundwater dewatering bores;
- Plant site;
- Dust suppression around the project area; and

- Potable water use and sewage treatment.

The requirements of the Lumwana Estate are yet to be incorporated into the model, although these requirements are expected to have a minimal impact on the overall site water management system. It is anticipated the Estate and the Project will utilise common potable water treatment facilities and sewage facilities to ensure best possible use of the resource and minimise impacts. Based on the following summary and the fact that the project, as it is currently modelled will operate in a positive water balance, there is not expected to be a shortage of water.

The water management model can be summarised as follows:

- The TSF and the site in general are anticipated to operate in positive water balance due to the large catchment areas reporting to the TSF and water storage facility. It is predicted that these two storages will meet the entire site and process water needs throughout the mine life;
- Modelling of drier than average climate conditions, up to a 1 in 20 dry year, at various times in the mine life indicates that water supply to the plant and other requirements can be met at all times; and

Although the site in general reports a positive water balance, the site water management indicates that the water dam will be required to supplement water recycled from the TSF (i.e. the TSF and plant site is a negative water balance system ensuring all contaminated water is recycled).

4.15.1 River Diversion

A diversion will be constructed to divert the Lumwana East River around the Malundwe open pits and the TSF. It consists of around 20 km of diversion channels to be constructed in three stages and two main diversion dams, the Lumwana Dam and the Chimiwungo Dam both with final heights of 30 metres. In addition, there will be 7 other smaller dams with final heights ranging from 5 to 20 m.

The diversion channel will consist of engineered channels that will be constructed to divert the 100 year/24 hour storm event (storms greater than this will report to the TSF). This diversion would also capture runoff from the Chimiwungo and Malundwe streams.

4.15.2 Surface Water Drainage and Infrastructure

Site drainage will be controlled by a comprehensive drainage network of open drains (including the river diversion described in 4.15) and subsurface pipes supported by the main water storage dam and smaller dams for specific use such as dust suppression on haul roads.

4.16 Power Supply

The national power grid, small-scale hydroelectric power stations and large diesel generators provide electrical power in the North Western Province of Zambia.

A 330 kV line has recently been constructed from Chingola to Solwezi to provide power for the nearby Kansanshi Copper Project. This supply will be part of the national grid of the Zambian Electricity Supply Commission (ZESCO) which is linked to the Southern Africa grid to support power supply to the country.

A 65 km 330 kV transmission line will be constructed as part of the project development from the Kansanshi sub station in Solwezi to the project site ending with a 330/33 kV substation. This will provide sufficient power for the project's requirements as well as for the newly constructed housing estate.

The 330 kV power line will be extended from Solwezi to Lumwana and is sufficient to enable the supply of the Project's power requirements.

4.17 Transport Infrastructure

4.17.1 Public Roads

As discussed in 3.15.14, the Mwinilunga-Solwezi T5 main trunk road (Northwest Highway) links the Solwezi district to the Copperbelt and other parts of the North Western Province.
The road from Solwezi to Lumwana is in poor condition and it is anticipated that the GRZ will upgrade this road to cater for the development of the region, in particular the Lumwana Project. The upgrade of this road is imperative for the success of the project.

4.17.2 Airstrip

Main access to Lumwana will be via road. Emergency and medivac air facilities will be required on occasion during the construction and operational phases of the project.

The nearest airstrips are located at Mwinilunga, 84 km west of Lumwana and at Solwezi, 65 km to the east. It is anticipated that should an airstrip be required, Solwezi would be utilised.

4.18 Site Management and Workforce

4.18.1 Construction

It is estimated during the construction phase of the project, employment will be generated for between 1,500 and 2,000 people. 80% of these jobs will likely be Zambian nationals. Additional jobs will be generated in the service sector in Solwezi and on the Copperbelt.

Management of the construction phase will be undertaken by ECV and the EPCM's (Engineering, Procurement and Construction Manager) supervisory team. The ECV team will consist of management and technical staff and will be located on site at Lumwana. The principal positions will be as follows:

- Managing Director
- Finance Director
- Mining Manager
- Maintenance Manager
- Processing Manager
- HSE Manager
- Construction Manager
- Industrial Relations Manager
- Community Relations and Business Development Manager
- Training and Development Superintendent.

The EPCM's supervisory team will report to the ECV team and will be accountable for the daily supervision of the contract workforce.

4.18.2 Operations

Operational personnel will number around 1000.

Management of the operational phase will be undertaken by a site based ECV management and technical supervisory team and ECV operational personnel supported by a range of specialist contractors. The principal positions will be the same as for the construction phase and in the short term undertaken by mostly expatriate personnel but with training and support to ultimately be undertaken by Zambian nationals.

4.18.3 Rosters

A range of rosters will be applied to meet the construction and operational requirements of the Project. The rosters may include:

- Monday to Friday;
- Six days on and three days off;
- Three weeks on and one week off;
- Three months on and one month off, and
- Five months on and one month off.

Rosters for the contract work force will be negotiated at the time of tender but will be negotiated to fit with the staff rosters selected.

4.19 Accommodation

ECV, via a local consortium of developers plans to construct a self sustaining community for the accommodation of all its employees, known as the Lumwana Estate (as shown in Figure 4-6).

The estate will initially be constructed to support single accommodation during the construction phase which at the operational phase, will be converted to a range of high, medium and low density housing options. The first stage will involve 1200 dwellings with potential to upgrade to 3000 dwellings dependant on expansion possibilities for the Project in the future. The Estate will also support a range of other infrastructure including:

- Hospital/medical centre;
- Schools – basic, middle and potentially tertiary;
- Shopping centres;
- Small business area; and
- Sports and cultural facilities.

The intention is that housing will be sold to ECV employees with an affordable repayment scheme.

A separate EIA will be submitted for construction of the Lumwana Estate. The developer is planning to submit the EIA well prior to construction of the permanent accommodation. At this stage, submission is planned for late 2005.

For the purposes of this report, the accommodation requirements for the construction phase of the project are included as part of this EIA.

4.19.1 Construction Phase

The construction phase of the project will involve a build up of up to 2,500 personnel, most on short-term (3-12 month) assignments requiring basic but functional accommodation. There will be little married accommodation at this stage of the project. This will involve:

- Single room accommodation
- Communal showering and ablution facilities; and
- Catering and wet mess facilities.

The construction phase accommodation requirements will increase from 50-100 rooms during the first quarter of 2006 to a peak of 2,500 rooms in the first quarter of 2007. The construction phase is planned to be complete by the end of the second quarter in 2007 there will only be a requirement for some 1,000 rooms.

4.19.2 Construction Methodology

The hydraform building system will be utilised for the construction of the houses. This is largely due to the limited availability of adequate aggregartes for block manufacture. Hydraform blocks are constructed using sub-soil and high compression without the need for fuel used for firing of conventional bricks.

The bricks are interlocking in nature and therefore don't require the use of mortar except in the ring beam, high gables and foundations.

Utilising this sytem will simplify the construction process for the construction phase and into the operational phase.

For example the shell of the primary school will be constructed at the beginning of the construction phase; this will then be partitioned off to create 120 rooms. Once mine construction has been completed, the interior partitions will be removed and the class rooms completed.

4.19.3 Support Infrastructure

Water Supply

Water supplied to the mine will also supply the Estate. Although the requirements are yet to be incorporated into the water balance described in section 4.15, it is a positive water balance and estate requirements are minimal in comparison.

Sewerage Treatment

The Estate is to be fully serviced with mains sewerage connecting all domestic and commercial properties to the system.

It is currently porposed to utilise conventional oxidation ponds comprising primary and secondary ponds operating qas a facultative-aerobic pond system. The system will be designed with multiple ponds allowing a twin operation to allow for flexibility in maintenance operation.

The ponds are to be located on the downstream side of the river diversion. This is to ensure sewerage lines do not pollute this water.

Full details on this system will be included as part of the Estate EIA discussed in Section 4.19.

Storm Water

The Estate road system will be designed to ensure storm water can be diverted around disturbance areas and allowed to discharge into existing natural drainage system.

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5. HEALTH, SAFETY, ENVIRONMENT AND SOCIAL ISSUES AND MANAGEMENT

5.1 General Health, Safety, Environment and Social Management

ECV has in place a Heath, Safety, Environmental and Social Policy, incorporating the key issues in health, safety, environment and social commitment of the company. A copy of the Policy is presented as Appendix C. The Policy provides the basis for doing business; a set of guiding principles and commitments ECV will implement as part of its day to day activities.

The Policy will be communicated to all employees and contractors who will also be provided with training on the intent of the Policy

5.2 Management System

ECV will develop and implement a Health, Safety and Environmental Management System (HSEMS) to manage its related health, safety and environmental related aspects in a manner that is planned, controlled, monitored, recorded and audited.

The HSEMS will follow the requirements of ISO 14001 and is based on the concept of continuous improvement and the key elements of Policy, Planning, Implementation, Checking and Corrective Action and Review. The design will be largely driven from the framework of ISO 14001 with additional emphasis on stakeholders and risk management.

5.3 Incident Reporting

A rigorous audit and inspection program will be undertaken on a regular basis to identify non-compliances and incidents. All incidents, including near miss and hazards, whether they are to people, the environment or equipment will be reported through the site HSEMS. All incidents will be investigated and assessed in a four step process that involves:

- Incident reporting;
- Incident investigation;
- Corrective action; and
- Communication and reporting.

5.4 Inductions

All personnel and visitors who come to the mine site and who are intending to work are required to successfully complete an induction. The induction will include information on health, safety, emergency procedures and environmental issues.

There will also be area specific inductions that cover:

- Mining; and
- Processing and maintenance.

After successful completion of the required inductions, personnel are able to work on site.

For visitors who are only on site for a short period of time, a short 15-20 minute induction will be utilised to ensure essential information is communicated. After this induction, a visitor must be escorted by a fully inducted person at all times.

5.5 Area of Disturbance

The majority of the area to be cleared for mining activities could be considered to be currently undisturbed aside from minor disturbance associated with previous exploration, agricultural activities and associated tracks.

As a result, disturbance of approximately 8,700 hectares of land will be required within LML-49. Approximately 5,000 hectares will be within the Forestry Reserve (around 8% of the total area of the Forest Reserve).

A procedure for clearance will be developed and implemented to ensure that any activities involving disturbance of the land do not occur until the environmental and heritage values have been assessed and the clearing approved by Environmental staff.

The areas to be impacted will be recorded on a disturbed land register and conditions may be imposed to minimise and/or mitigate any impact.

5.6 Environmental Issues and Aspects - Impacts

Environmental impacts are addressed by mine component. These are:

1. Open Pits;
2. Waste Rock Dumps;
3. Plant area, ROM Pad and processing facilities, including:
    - Ore crushing and transfer, and
    - Concentrator.
4. Tailings Storage Facility;
5. Lumwana East River Diversion system;
6. Workshop area;
7. Transport infrastructure (including concentrate transport);
8. Waste management, including:
    - Industrial waste,
    - Hazardous waste, and
    - Medical waste.
9. Materials Handling and Storage, including:
    - Mine stores, and
    - Fuel and hazardous materials.

The key environmental aspects/issues and associated impacts relate to each mine component and the pre-mining, operational and post closure phase where appropriate. They have been characterised using both qualitative assessment and quantitative evaluation where relevant data is available. The characterisation of these impacts and the criterion used to complete this are shown in Appendix D.

A total of 73 environmental impacts have been identified. Of these, 71 are negative and two are positive. It should be noted that a classification of negative does not necessarily imply a long-term adverse effect on the environment. It may well indicate an irreversible change to the physical environment from original conditions. In some cases, these irreversible changes can result in favourable long-term effects (for example the creation of a sailing or boating club on a tailings dam, such as the Rokana Boating and Sailing Club in Kitwe).

Negative impacts generally relate to physical disturbance of the land, surface and groundwater contamination, air pollution, soil contamination, noise, public and worker safety, plant spills and accidental releases, handling spills, inadequate waste management and sewage treatment/disposal. These potential environmental impacts with the exception of permanent changes to the physical landscape resulting from open pit excavation, tailings storage facility, water dam, river diversion and waste rock dump construction can be prevented or successfully mitigated against by implementation of a sound environmental management plan.

Positive environmental impacts relate to creation of new water resources for local communities in water dams and disused open pits.

For some impacts, further work is required to better understand the impact and mitigate against the impact. These will be included as part of the EMP and timing assigned to ensure completion.

Project environmental impacts and proposed mitigation measures are discussed by mine component in the following sections of this report. The Lumwana Environmental Management Plan (EMP) specifies management actions to prevent or mitigate potential environmental impacts. The EMP is discussed in Section 6 and is presented in Appendix E.

5.7 Open Pits

The aspects and impacts associated with the open pits are discussed in three phases:

- Pre-construction phase;
- Operational phase; and
- Decommissioning and Closure phase.

For each of these phases there are a range of impacts that have been recognised and these are discussed in each of the following sections.

5.7.1 Pre-Construction Phase

Site Clearance

The footprint of the Malundwe and Chimiwungo open pits covers a surface area of approximately 780 hectares. Site clearance will affect indigenous woodland areas, the Lumwana East River, the Chimiwungo Stream and wetland areas (dambo). All vegetation cover will be removed and animal life will be disturbed.

Clearance procedures are discussed in 5.5. These will be adhered to for the duration of the Project.

The main vegetation type in the area is Miombo woodland. The forest is in a state of regeneration following extensive logging for native hard woods that took place between 1960 and the early 1990's. The woodland has also suffered minor disturbance by mineral prospecting activities including construction of access tracks, trenching and drilling. Baseline vegetation surveys undertaken at the Malundwe and Chimiwungo open pit sites indicate that no rare flora species occur in the area except for the copper flower '*becium* homblei', which is found in copper clearings overlying the Malundwe deposit. Although rare, the copper flower is found elsewhere in Zambia growing in copper rich soils overlying deposits, which are unlikely to be mined or disturbed because of their small size or relatively low copper grade. Nevertheless ECV will attempt to preserve the copper flower at Malundwe by collecting specimens and transplanting them to specially prepared areas on the waste rock dumps where soil copper concentrations are adequate to sustain the plants. Other trees, shrubs, herbs and grasses present are found throughout the project area and regionally.

The baseline fauna survey indicated that only small mammals, reptiles, fish, birds and insects are present in the project area. Uncontrolled poaching and hunting has eliminated the larger game animals that were once prolific in the area some 35 years ago. None of the fauna currently found in the project area appears on the International Union for the Conservation of Nature (IUCN) critical list of endangered species.

Despite a certain loss of terrestrial and aquatic flora and fauna, site clearance for open pit mining at Lumwana is expected to have little impact on species number or diversity in the project area.

In order to fully utilise the timber resource and conserve the topsoil and forest litter for later use in site rehabilitation ECV will conduct site clearance in two phases:

- Commercial timber, if any, will be felled and removed by a Zambian logging company;
- In so much as it is practical to do so, the mine will strip and remove the remaining vegetation and topsoil and stockpile it for later use during progressive rehabilitation of the mine site.

Soil Erosion

Site clearance will leave soils exposed. Resulting soil erosion could impact on surface water quality. In order to minimise soil exposure and prevent/reduce soil erosion ECV will conduct site clearance no more than 6 months in advance of mining. In addition, storm water cut-off drains will be constructed around the perimeter of the open pits and silt traps will be constructed across all streams draining open pit areas, to settle suspended solids from surface runoff prior to release to the environment.

Surface Water

Contamination of surface water may occur as a result of the washing and maintenance of mine plant and equipment. ECV will construct an open pit workshop before commencing site clearance and mining operations. The workshops will have heavy equipment wash-bays equipped with impervious surfaces and containment to enable capture of all effluent from washing operations. Hydrocarbon traps will be installed in the workshop drainage system to treat all effluent prior to release.

To prevent possible contamination of soils resulting from fuel spills the open pit fuelling station will be bunded with impervious containment equivalent to 110% of the largest vessel in the fuel storage facility.

Public Safety

In order to prevent inadvertent access by the public into work areas, ECV will conduct a public awareness campaign through public consultation and liaison with local community leaders. Posters and warning signs will be displayed in villages and sensitive areas. The process plant area and workshops will be fenced off to further enhance security and public safety. Access to the operational areas will be via a guardhouse and security gate at the entrance to the site.

5.7.2 Operational Phase

Surface Water, Groundwater and Soils

Mine drainage water will be pumped from the open pit sump and to small storage dams where it will be utilised for dust suppression. It may also supplement the process water requirements. Excess water will be discharged to surface waters. To prevent surface water contamination as a result of pumping contaminated mine water directly into the Lumwana East River, mine drainage will be pumped to settlement ponds where solids will be allowed to settle. Analysis of water prior to discharge to the Lumwana East River will be undertaken to ensure discharge water meets regulatory requirements. These limits are included in Appendix F.

Effluent from operations at the open pit mine workshop may result in contamination of surface water with diesel, oils and grease via the mine drainage system. To avoid this, plant equipment will be washed in dedicated wash-bay areas equipped with impervious surfacing, containment and hydrocarbon traps. Hydrocarbon traps will be regularly monitored and emptied to avoid overflowing. Treated effluent will be discharged to the Lumwana East River, provided analysis confirms Zambian discharge limits are met. Hydrocarbon trap supernatant will be integrated into a waste-oil recycling programme and hydrocarbon trap residue placed in drums and stored in a dedicated area, awaiting disposal at an ECZ approved hazardous waste disposal site.

ECV will develop emergencey response procedures to be followed in the event of a hazardous material spill. This will:

- Define responsibilities;
- Specify notification requirements;
- Identify response actions;
- Itemise the necessary clean-up equipment; and
- Define clean-up objectives.

To prevent soil contamination, the service, maintenance and repair of open pit vehicles and equipment will only be carried out in dedicated areas specifically designed for this purpose. The movement of in-pit mobile fuel tankers and mobile electrical substations will follow specified procedures to avoid the contamination of soil from accidental releases of fuel and oil.

All open pit equipment that uses hydraulic fluid, oil, fuel or any substance that has the potential to contaminate surface water, groundwater or soil if released to the environment, will be subject to a preventative maintenance programme.

Contamination of soil and water may also occur as a result of inappropriate waste disposal practices. To avoid this, waste generated from the repair, maintenance or service of open pit equipment will be handled, stored and disposed of according to ECV's waste management strategy (key elements of which are summarised in the Environmental Management Plan, Appendix E).

Air Emissions

Open pit haul roads will be routinely sprayed with water to suppress dust generated by the movement of haul trucks and other heavy equipment. Dust generated at transient ore stockpiles and on the run of mine ROM ore pad will also be suppressed by water sprays. These may be fixed or mobile.

Blasting will occur regularly although it is of a short duration. ECV will implement a monitoring program prior to commencement of construction and continue through operation to ensure environmental and health and safety impacts are minimised as a result of air borne emissions and blasting effects.

Noise

The operation of mining equipment such as compressors, haul trucks, loaders and dozers will occasionally increase mine site noise levels. Current background noise levels are relatively low at around 15 - 30 dB. The Malundwe and Chimiwungo open pits are situated 4 km and 1.7 km respectively from the nearest villages, which straddle the T5 Solwezi - Mwinilunga road. It is therefore unlikely that noise from mining operations will be a nuisance to the villagers due to the distance and noise absorbing capacity of the woodland and rolling landscape. Blasting operations at Chimiwungo open pit will be audible but due to the infrequency and short duration should not be a nuisance to villagers. ECV will implement a program to monitor noise impacts.

Pit Wall Stability

Pit slope failure could result in the loss of additional peripheral woodland resources, mine equipment and pose a danger to workers and the public. In order to minimise the risk of slope failure ECV will implement erosion and storm water management measures. This will include the construction of diversion channels around the perimeter of the open pits and grading of the perimeter haul road to divert storm water runoff and surface drainage away from the pit and its slopes. Dewatering wells installed behind the high wall and in-pit pumping will control slope water pressures. The pit will be dewatered to prevent build up and accumulation of water. Silt settled in the open pit sump during the wet season will be removed as necessary during the dry season by hydro or mechanical means to ensure capacity for water to accumulate at the bottom of the pit. Safe and efficient blasting will be practiced at pit limits to preserve the final pit wall. In addition, the open pit rock mechanics engineer will regularly check and revise slope design as the pit is developed and additional data on the rock mass is collected. This will further minimise the risk of slope failure.

Water Table

In-pit pumping and the installation of dewatering bores to de-pressurise the pit wall will lower the general water table in the vicinity of the open pit. This could impact on any groundwater users in the area and shallow wells might dry up. Currently, the only domestic wells in the area are located in the villages close to the T5 main road. Hydrological studies indicate that these wells are beyond the draw down influence of the Malundwe and Chimiwungo open pits. However, the wells along the T5 road will be regularly monitored by ECV to verify any impact on water levels. Open pit dewatering is not expected to affect the flow of surface streams and rivers.

5.7.3 Decommissioning and Closure

Surface Water & Post Closure Pit Usage

Open pit dewatering will cease at mine closure and the pits will gradually fill with water. Flooding of the open pits by natural recharge from underground aquifers, direct precipitation and inflows from streams and rivers will create a series of small lakes.

At Malundwe, the Lumwana East River diversion system will be sealed and the river diverted into the Malundwe east pit. When full, the Malundwe east pit will overflow into the Malundwe main pit, which will in turn fill and overflow into the original Lumwana East River channel.

At Chimiwungo, the Chimiwungo Stream will flow into the main pit, which will overflow into the Chimiwungo Stream. The Chimiwungo south and east pits may not overflow because no significant watercourses flow into them.

The flushing of the main pits by natural surface streams combined with the positive results of geo-chemical characterisation studies on Lumwana copper tailings and the pre-mining groundwater quality in the area (Section 3.6) indicate that the quality of water in the flooded pits will be adequate to support one or more sustainable post closure uses. Research will be undertaken during the operational phase of the Malundwe pits to confirm expected water quality and volumes in the pits.

Several potential post closure uses for the flooded pits have been identified. These include recreational activities such as fishing and sailing, agriculture/irrigation, aquaculture and an aquatic nature reserve.

Pit Wall Stability

Post closure long-term pit wall stability will be assessed during the life of the mine. Results of stability analyses will be used to design safe final pit walls.

5.8 Waste Rock Dumps

The key issues of the waste rock dumps are discussed in two phases. That is:

- Development phase; and
- Operational phase.

Rehabilitation of the waste rock dumps is considered part of the operational phase as this is a progressive activity undertaken in conjunction with mining activities.

For each of these phases there are a range of impacts that have been recognised and these are discussed in each of the following sections.

5.8.1 Development Phase

Site Clearance

The combined footprints of the Malundwe and Chimiwungo waste rock dumps cover a surface area of approximately 1,950 hectares. Site clearance will affect indigenous woodland areas, the Lumwana East River, and wetland areas (dambo). All vegetation cover will be removed and animal life will be disturbed and/or lost. Similar flora and fauna types are found in the Lumwana open pit and waste rock dump areas with the exception of the copper flower, which is found only in the copper clearings at the Malundwe deposit. Mitigation measures associated with site clearance in waste rock dump areas are the same as those proposed in 5.7.1.

Surface Water

The Malundwe waste rock dump will be the first waste rock dump constructed at Lumwana. Site clearance may result in soil erosion and possible contamination of the Lumwana East River. Prior to the commencement of site clearance operations ECV will construct an engineered temporary settlement dam with spillway across the Lumwana East River at the western boundary of the Malundwe open pit to settle solids washed into the river via surface runoff. During the pre-construction phase a series of cascading sedimentation ponds and a final collection pond will also be constructed at the adjacent to the western toe drain of the dump. These will be utilised through to closure. Clean water from the collection pond will be utilised on site and any excess discharged into the Lumwana East River once discharge limits are compliant.

Mining of the Chimiwungo open pits is planned to start in project year 5. A system of water storage dams and silt traps will be incorporated into the drainage system for the Chimiwungo waste rock dumps to allow use of the water wherever possible and discharge of excess into the Chimiwungo Stream provided discharge limits are met.

5.8.2 Operational Phase

Dump Stability

To control runoff and sediment from dump walls and to minimise erosion ECV, will implement the following procedures:

- As far as it is practicable to do so, heavily weathered materials and rock types prone to erosion will be identified and placed in central areas well away from dump walls. Conversely, more competent, less weathered materials will be used to construct the outer dump walls and to dress the slopes;
- Dump walls will be constructed with overall slope angles of 20°, and inter-berm slope angles of 23°. They will incorporate 40 metre vertical height benches formed at face angles of 23°, separated by 20 metre wide berms.;
- Dumps will be of terrace construction i.e. there will be no end-tipping;
- Dump construction will be regularly monitored to verify that it is as per design; and
- Perimeter drains and silt traps will be regularly inspected and maintained. Drains and silt traps will be cleaned before the start of each wet season.

Re-vegetation of the dump walls and upper dump surfaces will be conducted progressively during the life of the mine to produce a sustainable vegetation cover, stabilise slopes, improve visual aesthetics and minimise post closure re-vegetation requirements. The re-vegetation programme will focus on the establishment of an indigenous vegetation cover in keeping with the surrounding area. The re-vegetation strategy will be a combination of natural re-vegetation supplemented by trees, shrubs and grasses. Wherever possible, seed will be collected locally to ensure local provenance. Stockpiled topsoil, organic matter, other bio-degradable material, and potentially fertiliser will be used to improve the soils and encourage plant growth.

Groundwater & Surface Water - Acid Rock Drainage (ARD)

Characterisation of the waste rock is discussed in 4.12.1 and as a result, ARD is not expected to result from the waste rock dumps. Monitoring will be undertaken for the life of the project and appropriate mitigation measures implemented should monitoring indicate potential issues.

Surface Water

In order to control surface runoff and prevent erosion of waste dumps:

- Contouring and profiling of the surface of the dumps will be undertaken to ensure surface and slope runoff will generally be directed to perimeter drains and sedimentation dams in a controlled manner;
- Successive lifts of the Malundwe waste rock dump will contoured and profiled so that all upper surface runoff flows east and south into the TSF where suspended solids will settle out;
- Prior to any discharges to the aquatic environment, analysis will confirm that the quality of the water is within the statutory limits.

In order to prevent the possible contamination of surface water as a result of inadequate waste handling or disposal practices, non-hazardous waste will not be stored on waste rock dumps unless done in accordance with ECV's Waste Management Strategy and then only in designated areas.

Uranium baring ore will be encapsulated in the waste rock dumps in designated areas and surface flows diverted away from the zones to minimise infiltration.

Air Emissions

Dust generation from the movement of haul trucks and other heavy equipment on the mine dumps will be suppressed by routine spraying with water. Monitoring will be undertaken to confirm mitigation measures are adequate

Noise

The Malundwe waste rock dumps are situated 4 km from Mafuta, the closest village situated on the T5 Solwezi - Mwinilunga highway. It is unlikely that noise generated from dumping operations at Malundwe will be a nuisance to the residents of Mafuta Village because of the distance and noise absorbing capacity of the woodland and rolling landscape.

By contrast, the Chimiwungo waste rock dumps are located much closer to villages straddling the T5 Solwezi - Mwinilunga highway. The southern boundary of the closest dump is approximately 750 meters from Chinyanga, Makonda and Kahumuna villages. Dumping operations will be audible during the day and night and could be a nuisance to the local community.

Mine optimisation studies indicate that it is not feasible to relocate the Chimiwungo dumps due to the limited availability of suitable land within viable tramming distances from the mine. ECV will discuss this issue with the Chief and local community through the public consultation process. Where practicable, dump construction will be sequenced to provide a waste rock noise barrier between dumping operations and affected villages. If physical observations indicate that the noise from dumping operations is a nuisance, an ongoing 24 hour monitoring programme will be implemented to quantify noise levels and the results used to develop appropriate additional mitigation measures. At the same time ECV will set up a noise complaints register. All complaints will be investigated to determine the cause and identify appropriate corrective action. Waste rock dumping at Chimiwungo is planned to start in Year 5 and continue for 13 years.

Archaeological Sites

As part of the project environmental baseline study the National Heritage Conservation Commission of Zambia (NHCC) conducted a cultural/archaeological survey of the immediate project area. The survey discovered four archaeological sites in close proximity on the south bank of the Lumwana East River (refer to Section 3.10 of this report). The archaeological sites comprise pockmarks and incised strokes on rock outcrops located within the footprint of the waste dump.

Following recommendations made in the NHCC report and should the project proceed to development, ECV will fund the removal of the rock engravings to an NHCC approved location for preservation and display. The prehistoric sites will be fully documented and recorded. Further studies may be conducted prior to commencement of clearance activities if further sites are suspected.

Aesthetics and Rehabilitation

The Malundwe waste rock dumps are situated more that 4 km north of the T5 main road. The highest part of the dumps will attain a maximum elevation of 1393m amsl approximately the same elevation as the T5 main road. The Malundwe dumps will therefore be screened by the Miombo woodland and will not be visible from the main road.

The Chimiwungo waste rock dumps are situated at least 1,000 metres from the main T5 road. The mine dumps have been designed so as not to be visible from the road.

In order to further lessen the visual impact of the dumps ECV will implement a progressive dump re-vegetation programme. The programme will focus on establishing a sustainable native vegetation cover that blends in with the surrounds. Species selection will be done in consultation with the Forestry Department of the Ministry of Environment and Natural Resources in Solwezi and local provenance seeds will be used wherever possible.

Public Safety

In order to prevent inadvertent access to dumping areas by the public, ECV will conduct a public awareness campaign through public consultation, liaison with local community leaders, and the display of posters in villages. Warning signs will be erected at appropriate access points.

5.9 Plant Area, ROM Pad and Processing Facilities

The key issues of the waste rock dumps are discussed in two phases. That is:

- Construction phase; and
- Operational phase.

The operational phase considers the ore crushing and transfer areas and concentrator separately.

For each of these phases there are a range of impacts that have been recognised and these are discussed in each of the following sections.

5.9.1 Construction Phase

Site Clearance

The footprint of the ROM pad and Plant Area covers a relatively small surface area of approximately 60 hectares. Site clearance will affect rejuvenating indigenous Miombo woodland. All natural vegetation cover will be removed and animal life will be disturbed and/or lost. Similar flora and fauna types are found in the waste rock areas. Mitigation measures associated with site clearance for the ROM pad and Plant Area are described in Section 5.5.

Surface Water

Contamination of surface water may occur as a result of soil erosion and runoff during site clearance. Storm water cut-off drains will be constructed around the perimeter of the ROM Pad and Plant Area to intercept slope runoff and divert drainage around the construction site. The storm water drains will discharge into the Lumwana East River diversion channel or the Chimiwungo Dam.

Management of Contractors

Unless properly managed, contractors involved in the construction of the plant site are likely to disturb the environment through waste generation, excavation, tree felling and unauthorised construction.

In order to effectively manage the contractors, environmental management requirements will be incorporated into all contract documents between the contractor and ECV. In addition, the principal contractor will submit a Construction Environmental Management Plan for approval by ECV's HSE Manager. Contractors will be monitored and audited against environmental requirements specified in the contract. The principal contractor (all its employees and sub-contractors) will be required to attend an ECV induction as discussed in 5.7.

Waste materials generated at the contractor's accommodation areas will be handled according to ECV's waste management strategy and contractors will be responsible for the reinstatement of disturbed areas to meet ECV requirements.

5.9.2 Ore Crushing & Transfer - Operational Phase

Air Emissions

Air-borne dust will be generated from the ore stockpile, crushing plant and bulk ore transfer points. Dust blow from the ROM pad will be suppressed by spraying water from water carts. Water sprinkler systems will be installed in the crushing plant, at bulk ore transfer locations and overland conveyor systems (if required) to suppress dust. Air quality control equipment will be installed in critical areas to assess the performance of the dust suppression systems. Monitoring will be undertaken to ensure management measures are performing as expected.

Surface Water

Runoff from the ROM pad will contain silt, which if not managed may contaminate surface water. Over time, silt in runoff may change the character of the Lumwana East River due to solids deposition. To mitigate these potential impacts, storm drains will be constructed to intercept runoff from the ROM pad area. The drains will discharge into sedimentation ponds where solids will settle. Clear water will be returned to the plant for use as process water or discharged in to the diversion system. Sedimentation pond sludge will be returned to the process.

5.9.3 Concentrator - Operational Phase

Air Emissions

Dust due to exposed concentrate stockpiles may result in air pollution. To prevent dust, concentrates will only be stored in appropriately constructed designated storage areas.

Surface Water

Contamination of surface water may occur resulting from the contact between storm water and concentrate and/or tailings. To prevent the carry over of concentrate and/or tailings into the plant site drainage system, plant spills will be collected in sumps and pumped back to the process. Storm water drains in the concentrator area will be kept clear of solids and debris to prevent overflow into operational areas.

Surface Water, Groundwater and Soils

Spills and/or accidental releases due to overflow from oil traps, equipment failure, inadequate handling, storage and transport of process reagents and chemicals, or tailings pipeline failure could result in surface water, groundwater or soil contamination. To mitigate against these potential impacts:

- Hydrocarbon traps will be installed around machinery in the mill to contain spillages;
- All process tanks, pipes, pumps, tailings delivery pipelines and other equipment will be subject to a preventative maintenance programme. Equipment, containment areas and the tailings delivery pipeline will be regularly inspected and documented;
- Handling, storage and movement of reagents and chemicals will be done according to procedures outlined in Section 5.12.1. Reagent storage and containment areas will be regularly inspected;
- In the event of a spill, spill response procedures and measures will be implemented. The area will be isolated and the spillage cleaned-up as soon as possible;
- Process reagents and chemicals will be tracked through an inventory system;

5.10 Tailings Storage Facility

The aspects and impacts associated with the TSF are discussed in three phases:

- Construction phase;
- Operational phase; and
- Decommissioning and Closure phase.

For each of these phases there are a range of impacts that have been recognised and these are discussed in each of the following sections.

5.10.1 TSF – Construction Phase

Site Clearance

Site clearance will affect the fringes of Miombo woodland adjacent to wetlands (dambos) running along the Lumwana East River for several kilometres upstream of the Lumwana Dam wall. All woodland vegetation cover will be removed and animal life will be disturbed and/or lost. Similar flora and fauna types are found in the Malundwe open pit and waste rock dump areas, ROM pad and plant area. Mitigation measures are discussed in section 5.8.

Construction of the TSF dam wall will flood the Lumwana East River valley for several kilometres upstream. The aquatic flora and fauna in the river, its tributaries and peripheral dambo areas will be adversely affected. Although construction of the TSF will have a permanent impact on this stretch of river, the aquatic flora and fauna of the river and adjacent wetlands is not unique and all species are common both upstream and downstream of the project area.

5.10.2 TSF – Operational Phase

Tailings Deposition

Sub-aerial deposition of tailings in the Lumwana tailings storage facility will further impact on the aquatic flora and fauna of the Lumwana East River. The valley floor will be buried in tailings to a depth of 25 to 30 metres. Aquatic flora and fauna in areas affected by tailings deposition will be lost. However, as stated previously, the aquatic flora and fauna of the river and adjacent wetlands is not unique and all species are common both upstream and downstream of the project area.

Air Emissions

Potentially during the dry season there may be exposed beaches of tailings which could result in dust from the surface of the TSF. Dust generation from exposed tailings surfaces may result in local air pollution and possible soil contamination in the vicinity of TSF. The impact of air emission both from an ambient dust perspective and potential Radon emissions as a result of the low uranium levels in the tailings will be monitored throughout the operating life of the TSF.

Surface Water

Overflow of supernatant in times of peak rainfall may occur into Lumwana East River diversion system and could impact on river water quality.

Plant metallurgical testwork undertaken by Ammtec Limited (2002) and tailings characterisation studies conducted on Malundwe ore by Graeme Campbell & Associates (2002) as part of the Project Bankable Feasibility Study (Golder, July 2003) indicates that the TSF supernatant (tailings solution) will comply with the Zambian environmental standards and World Bank Guidelines for effluent discharge to surface waters. Table 5-1 summarises the expected parameter concentrations in the TSF supernatant discharge, and relevant environmental standards. Effluent discharge is not expected to adversely affect adjacent watercourses.

As discussed in Section 3.7.7, at the time of the baseline study, maximum average levels of uranium concentration were being recorded up to 0.13 mg/L. There are no Zambian standard or World Bank guideline regulating uranium concentration in effluent discharge to surface waters, the uranium concentration in the TSF supernatant is very low (0.16 mg/L) and significantly lower than the US Environmental Protection Agency (EPA) standard for effluent discharge from a uranium mill (2 mg/L - 30 day average and 4 mg/L - maximum for any one day). The uranium concentration in the TSF supernatant is not significantly higher than the USEPA standard for uranium in drinking water (0.03 mg/L).

No testwork has been conducted to determine the likely concentration of Radium-226 in the tailings supernatant. However, a radiological specialist Dr. Rian Strydom, Director, PACC Scientific (Pty) Ltd was consulted for a professional view and judgement on this issue (refer to Dr. Strydom's letter of 16 May 2003 presented in Appendix H). Based on typical Ra/U activity ratios in uranium mines in South Africa and USA, and the low levels of uranium in the tailings supernatant at Lumwana, Dr. Strydom concluded that Ra activity is unlikely to reach values where effluent limits will be exceeded. This refers to USEPA effluent limits of Radium-226 0.37 Bq/l 30- day average and 1.11 Bq/l - maximum concentration for any one day. Radium-226 concentration in the TSF discharge will be monitored weekly as part of the Environmental Monitoring Plan (refer to Section 5.3.1 - Surface Water Monitoring).

Contamination of the Lumwana East River could occur due to elevated levels of suspended solids in the TSF supernatant discharge. To prevent this ECV will control/monitor the settling of solids in the TSF to ensure adequate residence time. Only clear supernatant will be discharged to the Lumwana East River diversion system in times of peak flow. The Lumwana tailings are relatively coarse (80% minus 300 μm) and thus, will settle very quickly in the TSF pool. The Zambia standard and World Bank guideline for TSS in effluent discharge is 100 mg/L and 50 mg/L respectively.

Any volume discharged will be monitored to verify compliance with regulatory standards.

Groundwater & Surface Water - Acid Rock Drainage

Characterisation of the tailings material is discussed in 4.13.3 and as a result, ARD is not expected to result from the TSF. Monitoring will be undertaken for the life of the project and appropriate mitigation measures implemented should this indicate potential issues.

Soils

Contamination of soils may occur along the tailings delivery pipeline running between the concentrator and the TSF dam due to leaks, spills and accidental releases. To prevent this occurring, the tailings delivery pipeline will be placed in a bunded channel that will contain any tailings spills. The pipeline channel will have a sufficient gradient to allow the tailings to drain into the tailings storage facility. In case any tailings escape the channel, they will be picked up and removed to the TSF.

Table 5-1: Tailings Storage Facility – Likely Effluent Quality Compared to Zambian Discharge Standards and World Bank Guidelines (Supernatant)

Parameter	Parameter Concentration mg/L except pH & EC μS/cm	Effluent Discharge Standards/Guidelines	
		Zambia	World Bank
Major Parameters			
pH	7.6	6.0 - 9.0	6.0 - 9.0
Electrical Conductivity	1,200	4,300	-
Total Dissolved Solids (TDS)	680	3,000	-
Major-Ions			
Magnesium - Mg	14	500	-
Chloride - Cl	170	800	-
Sulphate - SO_4	150	1,500	-
Nitrates - NO_3-N	0.25	50	-
Ammonium - NH_3-N	<0.1	10	10
Minor-Ions			
Iron - Fe	<0.01	2.0	2.0
Copper - Cu	<0.01	1.5	0.5
Zinc - Zn	<0.01	10	2.0
Nickel - Ni	<0.01	0.5	0.5
Cobalt - Co	<0.01	1.0	-
Aluminium - Al	0.03	2.5	-
Manganese - Mn	0.4	1.0	-
Cadmium - Cd	<0.01	0.5	0.1
Lead - Pb	<0.01	0.5	0.1
Chromium - Cr (Hexavalent)	<0.01	0.1	0.1
Mercury - Hg	<0.001	0.002	0.01
Arsenic - As	<0.001	0.05	0.1
Antimony - Sb	0.001	0.5	-
Bismuth - Bi	<0.01	-	-
Selenium - Se	0.004	0.02	0.1
Boron - B	0.04	0.5	-
Fluoride - F	1.0	2.0	20
Molybdenum - M	0.019	5.0	-
Phosphorous - P	<0.1	-	2.0
Silver - Ag	<0.001	0.1	0.5
Barium - Ba	0.017	0.5	-
Strontium - Sr	0.60	-	-
Thallium -Tl	<0.0001	0.5	-
Vanadium - V	<0.01	1.0	-
Tin - Sn	<0.001	2.0	-
Uranium - U	0.16	Nil	-
Thorium - Th	<0.0001	-	-

Incident/Safety

Dam wall stability could be at risk from over-topping, a high dam wall phreatic surface or incorrect tailings deposition practices.

ECV will operate the tailings disposal facility in accordance with procedures outlined in the designer's Tailings Operating Manual.

In addition, dam wall freeboard and piezometric levels will be regularly monitored. A competent person will conduct and document frequent inspections of the facility.

Public/Worker Health & Safety - Radiation Exposure

Workers and the public will be exposed to low levels of radiation from exposed copper tailings containing low concentrations of uranium. For the protection of members of the public and radiation workers the International Commission for Radiological Protection (ICRP) recommends that the additional radiation dose above the natural background level should be limited to 1 mSv/yr for members of the public and 20 mSv/yr averaged over 5 years for radiation workers (mine workers). These limits are more conservative than those specified in current Zambian Legislation (50 mSv/yr for workers and 5 mSv/yr for the public).

An individual working at the TSF could receive the maximum recommended radiation dose limit of 20 mSv/yr from 4 possible sources:

- External radiation from exposed tailings;
- Inhalation of radon gas emissions from tailings;
- Inhalation of tailings dust; and
- Ingestion of contaminated tailings effluent.

Table 5-2 describes the types of exposure at a uranium tailings dam and the equivalent effective dose.

In a worse case scenario based on an 12 hour working shift (over a continuous shift panel averaging 243 hours per month) it would not be possible for a Lumwana mine worker to receive in excess of 13.7 mSv/yr resulting from the combined external radiation on bare tailings, inhalation of radon gas from tailings and inhalation of tailings dust. This is well below the ICRP radiation dose standard of 20 mSv/yr. Taking into consideration the dilution effect, the low grade of the ore and minimal exposure of tailings due to the sub-aqueous deposition, annual maximum radiation doses from exposure of workers at the TSF are likely to be significantly less than 13.7 mSv/yr.

Access to the tailings disposal facility will be restricted. ECV will inform the public of the dangers of entering areas of operations via public consultation, liaison with community leaders and erecting warning signs.

Table 5-2: Radiation Exposure and Equivalent Effective Dose

Type of Exposure	Amount and Type of Radioactive Substance	Length of Exposure	Equivalent Effective Dose
External radiation on bare tailings surface.	Tailings derived from an initial ore grade of 0.1% (1000ppm).	Continuous exposure for 1 year.	36 mSv/yr
Inhalation of radon gas emissions from TSF.	Radon gas concentration of 148 Bq/m^3 in air (0.1% ore grade).	Continuous exposure for 1 year.	3.3 mSv/yr
Inhalation of tailings dust.	253 $\mu g/m^3$ of dust arising from tailings from 0.1% uranium ore.	Continuous exposure for 1 year.	1 mSv/yr
Ingestion of contaminated effluent.	1.6 mg/L of pure natural uranium in drinking water.	Continuous exposure for 1 yr (500 litres/yr).	1 mSv/yr

(Source USEPA, Office of Radiation Programs)

5.10.3 TSF – Decommissioning and Closure

TSF Surface Area

Trials will be undertaken beginning around Year 6 to determine appropriate cover material for TSF to ensure a stable, sustaining vegetative cover can be created on the surface of the TSF. Profiling and contouring will be used to minimise ponding on the TSF surface once rehabilitated and direct surface runoff to the East Lumwana River.

Pit Wall Stability

Post closure long-term pit wall stability will be assessed during the life of the mine. Results of stability analyses will be used to design safe final pit walls.

5.11 Lumwana East River Diversion

The aspects and impacts associated with the diversion, that will be a permanent feature, are discussed in two phases:

- Construction phase; and
- Operational phase.

For each of these phases there are a range of impacts that have been recognised and these are discussed in each of the following sections.

5.11.1 Lumwana East River Diversion – Construction Phase

Site Clearance

Site clearance for the Lumwana East River diversion tunnel will affect a relatively small area of wetlands and Miombo woodland in and adjacent to the Chimiwungo Stream at the sites of the proposed dam walls.

Mitigation measures associated with site clearance in Miombo woodland areas are the same as those proposed in Section 5.8.

Lumwana East River

Flow in the Lumwana East River downstream of the project will be temporarily interrupted/reduced during the construction and filling of Lumwana Dam. This may adversely affect downstream water users, aquatic flora and fauna, and riverine vegetation. To mitigate this impact, ECV will ensure that as a minimum, the normal dry season river level is maintained throughout the year. To achieve this, water will be pumped from the river immediately upstream of the dam into the river diversion or into a pipeline running along the valley side, which will discharge back into the Lumwana East River. This water will be supplemented by mine drainage water from the Malundwe open pit. The flow volume in the Lumwana East River immediately downstream of the project will be monitored weekly during dam construction and filling to verify that minimum flow rates are being achieved and no adverse impacts are likely to occur.

5.11.2 Lumwana East River Diversion – Operational Phase

Public Safety

Lumwana East River Dam wall stability could be at risk due to a high phreatic surface or over-topping. Catastrophic failure of Lumwana Dam could result in erosion of the downstream TSF main wall and waste rock dump areas, inundation of the Malundwe open pit and possible early closure of the mine. Downstream flow rates in the Lumwana East River would also be affected until the open pit has fully flooded and overflowed into the original Lumwana East River channel. To minimise the risk of dam wall failure, Lumwana Dam will be operated strictly in accordance with the procedures contained in the Operations Manual provided by the dam design engineers.

Piezometers installed in the dam wall will be read regularly to monitor the dam wall phreatic surface. The dam structure and spillway will be regularly monitored and an inspection record kept at the mine. In an emergency, procedures detailed in the Emergency Response Plan (ERP) will be followed.

The Lumwana East River diversion could be affected by erosion, which may adversely affect the integrity of the diversion and its safe operation. Regular checks will be conducted to monitor performance of the diversion tunnel and identify any signs of erosion. This will be documented.

5.12 Plant Area Workshop

The aspects and impacts associated with the TSF are discussed respect of the operational phase.

5.12.1 Plant Area Workshop - Operational Phase

Contamination from Hazardous Materials

Contamination of surface water, groundwater or soil may occur as a result of inadequate handling or storage or accidental spillage of chemicals, acid, organic solvent, reagents, hydrocarbon and concentrate.

To prevent this, storage and handling of hazardous material will be in accordance with site procedures. This may mean that there are bunded, impervious areas, locked facilities or facilities protected from the weather.

Storage and handling will in accordance with manufacturer requirements specified in Material Safety Data Sheets. Site procedures will also be developed to ensure a clear understanding of all requirements this will include the assessment of any product prior to bring on site.

With regard to hydrocarbon storage and handling areas, hydrocarbon will be installed in all drains such that in the event of a spill any residue can be captured and recovered for disposal according to site procedures.

The washing of mobile equipment and machine parts will only be done in designated wash bay areas. Drainage from wash bays will pass through hydrocarbon traps prior to release into the site drainage system. Hydrocarbon traps will be regularly inspected, monitored and serviced. The hydrocarbon residue will be placed in drums and stored in an approved area for collection by a hydrocarbon recycling company. Sludge from hydrocarbon traps will be treated as a hazardous substance and disposed by at an ECZ approved site.

Poor housekeeping and spillage may also result in the contamination of surface runoff. To maintain good housekeeping and prevent spillage, the workshop areas will be regularly inspected as part of a preventative maintenance programme. All potential sources of contamination in the workshops will be monitored.

All storage and handling areas will be subject to regular inspections and audits. And all spills reported through the site incident reporting system.

All personnel involved in the ordering, storage, use and disposal of hazardous materials will receive training focussing on environmental awareness, safe handling procedures and spill reporting and spillage response/action.

5.13 Transport

Accidental Releases/Spills

Contamination of surface water, groundwater or soil may occur as a result of inadequate handling or storage or accidental spillage of chemicals, acid, organic solvent, reagents, hydrocarbon and concentrate.

To minimise the risk of accidental release or spill, the transport of hazardous materials, including copper concentrate, will be undertaken in accordance with site procedures.

These will include:

- Documentation and inventory control through chain of custody;

- Emergency response training for all relevant ECV and contractor's employees;
- Tracking and notification of shipment location and condition;
- Carrying of onboard emergency equipment;
- Vehicle road worthiness checks will be conducted and a preventative maintenance programme implemented; and
- Random and unannounced en route safety inspections.

Materials will be moved on designated transport routes only. An escort vehicle will accompany explosives trucks and all vehicles will be flagged.

Tarpaulins will be used to cover open top bulk copper concentrate transport trucks to prevent spills resulting from the exposure of concentrate to rain and/or wind.

All contracts with road haulage contractors will include clauses on Zambian and relevant regional/international standards relating to the transport of hazardous materials.

Contamination may also occur due to defective or damaged infrastructure. In this regard, ECV will implement a preventative maintenance programme on all mine roads, bridges, culverts and traffic signs to ensure all are maintained in good condition thereby minimising the probability of road accidents. Transport infrastructure will be inspected regularly.

Air Emissions

Air contamination may occur in the vicinity of the mine due to dust emissions from vehicles and trucks operating on unsealed roads. Water will be sprayed on all unsealed roads to suppress dust emissions from vehicle movements.

5.14 Industrial Waste Management

Industrial Waste Generation

Mine operations will generate significant quantities of scrap metal and general waste. ECV's Waste Management Strategy is based around the principles of:

- Reduce;
- Reuse; and
- Recycle

Reductions in the quantities of waste will be sought at all times and this will be applied to all contractors on site. All industrial waste will be disposed of according to the ECV's Waste Management Strategy with all waste being stored in secure areas and sorted to facilitate reuse and/or recycling.

Hazardous Waste Generation

The generation of hazardous waste on the mine such as used oil and grease may result in soil and/or water contamination. To prevent contamination, hazardous waste will be stored in a secure area.

The storage area will be equipped with a concrete floor and 110% containment. Non-compatible hazardous wastes will be stored at separate sites. Used oil will be sold to a recycling company and greases returned to the supplier according to approved disposal practices.

Medical Waste Generation

Inadequate disposal of medical waste from the mine clinic may result in contamination of soil, surface water or groundwater. All medical waste will be disposed of in accordance with the mine's Waste Management Strategy.

5.15 Material Handling and Storage

Contamination from Hazardous Materials

Contamination of surface water, groundwater or soil may occur as a result of inadequate handling or storage or accidental spillage of chemicals, acid, organic solvent, reagents, hydrocarbon and concentrate.

To prevent this, storage and handling of hazardous material will be in accordance with site procedures. This may mean that there are bunded, impervious areas, locked facilities or facilities protected from the weather.

Storage and handling will in accordance with manufacturer requirements specified in Material Safety Data Sheets. Site procedures will also be developed to ensure a clear understanding of all requirements this will include the assessment of any product prior to bring on site.

With regard to hydrocarbon storage and handling areas, hydrocarbon will be installed in all drains such that in the event of a spill any residue can be captured and recovered for disposal according to site procedures.

The washing of mobile equipment and machine parts will only be done in designated wash bay areas. Drainage from wash bays will pass through hydrocarbon traps prior to release into the site drainage system. Hydrocarbon traps will be regularly inspected, monitored and serviced. The hydrocarbon residue will be placed in drums and stored in an approved area for collection by a hydrocarbon recycling company. Sludge from hydrocarbon traps will be treated as a hazardous substance and disposed by at an ECZ approved site.

Poor housekeeping and spillage may also result in the contamination of surface runoff. To maintain good housekeeping and prevent spillage, the workshop areas will be regularly inspected as part of a preventative maintenance programme. All potential sources of contamination in the workshops will be monitored.

All storage and handling areas will be subject to regular inspections and audits. And all spills reported through the site incident reporting system.

All personnel involved in the ordering, storage, use and disposal of hazardous materials will receive training focussing on environmental awareness, safe handling procedures and spill reporting and spillage response/action.

5.16 Lumwana Estate – Construction Phase

Site Clearance

500 hecatares of land has been designated the area required for the Lumwana Estate. Whilst the Estate is to be constructed, managed and operated by an independent body, the clearing principles outlined in section 5.5 will apply. Where park and recreational areas are planned within the estate, some vegetation, including large trees, will not be cleared. This will be managed through the clearing procedures.

Soil Erosion

Site clearance will leave soils exposed and resulting erosion could impact on water quality. In order to minimise issues as a result of construction of the estate, clearing will only be undertaken prior to construction in an area. In addition, storm-water will be directed around disturbed areas and if required drain to a settlement pond to settle suspended solids prior to release to the environment.

Sewerage Treatment

As discussed in section 4.19.3, oxidation ponds will be utilised for sewerage treatment.

The base of the ponds will be constructed of compacted caly or lined if sufficient clay is not available to reduce the potential for groundwater contamination.

Public Safety

During the construction phase, work areas will be barricaded to prevent inadvertent access. ECV and the housing estate developer will also incorporate the Estate as part of the awareness campaign through public consultation and liaison with local community leaders to ensure work is undertaken with no additional risk teo the public.

5.17 Socio-Cultural and Economic Impacts and Mitigation Measures

Copper production on the Zambian Copperbelt has declined significantly over the last 30 years from a peak of around 700 ktpa to current levels of around 350 ktpa. With the development of the Kansanshi Project and potentially the Lumwana Project, it is probable that the focus of the Zambia copper industry will shift from the Copperbelt to the North West Province over the next 10. Key infrastructure such as transport and power will enable further development. Mining in the Province will have the advantage of state-of-the-art technology and lower production costs associated with open cut mines in addition to a greater level of awareness of social (and environmental) impacts and appropriate mitigation measures.

The development of the Lumwana Project is likely to create positive socio-cultural and economic impacts in an area, which has so far received no significant investment. Obvious positive impacts are the provision of employment and infrastructure in the local community and the multiplier effects of regional investment from the project. The following sections highlight the potential social-cultural and economic impacts of the Lumwana project on the local population.

5.17.1 Project Economic Impacts

Capital Investment

The BFS (completed in 2003) indicates that the Lumwana Project will require significant capital investment. This investment will be spent in two stages; about US$420 million will be spent in the first stage (mine infrastructure and copper plant to process Malundwe ore) and US$288 million in the second stage (construction of a roast-leach-electrowin plant to treat Chimiwungo concentrate). An additional US$114 million has been estimated for deferred and sustaining capital. These capital costs include the cost of the mining fleet. Capital spending will begin approximately 18 months prior to the commencement of production. The RLE expansion phase will start approximately 4½ years later. These cost estimates are subject to change.

Most of the money will be spent outside Zambia on the purchase of plant and equipment. However, ECV is committed, as far as practicable, to employing local contractors to provide engineering and non-engineering services during the construction and operation of the mine. In this regard ECV will implement a contractor engagement strategy that ensures local Zambian contractors are employed in preference to foreign contractors subject to their ability to carry out the work competitively and to the required standard.

To further promote local economic development ECV will evaluate/assess local business opportunities for each contract including the possibility of cooperation between local and foreign manufacturers. In addition, ECV will publish and distribute information explaining procedures on how to conduct business with ECV.

The off-site investment to extend the 330 kV power line from Solwezi to Lumwana is included in the initial capital cost but the ‘public infrastructure’ upgrade cost of improvements to the T5 main road is excluded. Dr. L Sondashi, Minister of Works and Supply wrote to Equinox on 10 July 2003 regarding the T5 road improvements. T5 road infrastructure development plans are being prepared and tenders for the rehabilitation of 276 kilometres of road between Chingola and Mwinilunga via Solwezi were advertised in the national press on 16 May 2003.

Employment

One of the direct positive impacts of the project is the generation of employment opportunities for local unskilled and semi-skilled workers and skilled mine workers from the Zambian Copperbelt and further a field. The project is likely to generate employment for up to 2000 people during construction and up to 1,500 once operations commence.

ECV will employ Lumwana locals, followed by Zambian citizens in preference to foreigners if they possess the necessary skills, qualifications and experience. The Company will endeavour to employ established Zambian contractors to undertake mining related activities and services such as ore grade control drilling, drill and blast, metal fabrication and machining etc. It is expected that the mine through the award of mine services contracts will indirectly provide employment for several hundred additional workers in Solwezi and on the Copperbelt and possibly further a field, through the employment multiplier effect.

ECV is an 'equal opportunity' employer. In practice this means that the 'best applicant for the job will be offered employment, regardless of gender or tribe. Additionally ECV will value its employees, promoting diversity and providing competitive compensation programmes consistent with performance and industry practice. The company is also committed to the safety, health, development and well being of its employees.

Employee salaries and conditions of service offered by ECV will be commensurate with that of other mining companies in the region.

Regional Investment

Regional spending in support of mining operations at Lumwana is another direct positive project impact.

It is expected that most of this expenditure will benefit Solwezi and the Copperbelt towns of Chingola, Kitwe and Ndola, which have well established mine service industries. Spending on contractors will be in addition to the above.

Corporate Social Responsibility (CSR)

More recently, in the mining industry worldwide, attention by governments, non-governmental organizations (NGOs) and the public have focused on the Developer's social responsibility initiatives and social development plans.

In this regard, ECV is committed to being a progressive and constructive partner to advance the economic, educational, and social infrastructure of the communities in which it will operate. However, ECV will not assume the old 'paternal' role that the former Zambia Consolidated Copper Mines (ZCCM) afforded its employees. In the ZCCM model, the Company provided free education, free housing, free medical care, subsidised maize meal, community services and recreational sports facilities to its employees and their immediate dependents. As a project developer ECV intends to focus on its core business of mining and mineral processing. Nonetheless, ECV intends to support the construction of facilities to service the local communities such as a school, clinic, police station and sports fields. These will be incorporated as part of the Lumwana Estate which will become a small regional centre.

In line with fulfilling its social responsibilities ECV will collaborate with Government Health Services in order to implement a malaria 'roll back' program to reduce the incidence of malaria in the project area. ECV will conduct malaria spraying at the mine site and assist the local health services with malaria control programmes in local villages situated close to the mine. An education and awareness programme has bee implemented on HIV/AIDS prevention which will be expanded.
During the five years it has been working in Lumwana, ECV has established good relations with Chief Mukumbi and the Mukumbi Royal Establishment. The following actions by ECV already demonstrate its commitment to assist the local community:

- ECV practices its commitment to employing local people. 160 Zambians were employed during the BFS exploration-drilling program in 2002. Of this number 120 were employed from the Lumwana area;
- Construction of permanent bridges across local streams and rivers to assist movement of people, especially during the rains when rivers are in flood;
- Construction of a health clinic and clinic accommodation block, which has been handed over to the local government; and
- Provision of transport to Chief Mukumbi and his Royal Establishment, to attend official functions and perform his royal duties.

In addition to the provision of facilities, the Company will develop and implement an active training and development programme for its employees. These job skills will give the workers mobility in the Zambian employment market.

Of the afore mentioned project contributions to local economic development the most significant is direct employment - the payment of salaries and wages to employees, which will in turn be spent in the Lumwana and Solwezi areas. At a national level, the Government Royalty Tax on metal, Company Tax and pay as you earn PAYE income tax on employee salaries will contribute to the development of the Zambian economy.

5.17.2 Socio-Cultural Impacts

Community Expectations and Concerns

Project development normally generates both expectations and concerns from the local community. The Lumwana Copper Project is no exception. The following expectations and concerns were expressed at the Public Consultation Meeting held at the start of the EIA process and in participatory rural appraisals PRA's (community meetings) held during the socio-cultural and economic baseline study:

Expectations:

- *The local people's expectation that 'they' will be employed by ECV*

  It is obviously not possible for everyone in the community to be employed by ECV, either because they are not suitably qualified for the position or jobs suitable for them have been filled. This will need to be communicated to the people through the local leadership.

- *Chief Mukumbi's expectation of wealth/direct financial support going to himself, his family and his kingdom; for example his request to be paid a mineral royalty and donation of a 4WD vehicle.*

  The Ministry of Mines should enter into dialogue with the Chief and explain to him that minerals in the ground are the property of the Zambian government and consequently, royalties are payable to the government.

Concerns:

- *Land squatting.*

  Local people have expressed anxiety that people will move into the immediate project area, building shanty type housing, and clearing state forest to grow crops. The Developer in collaboration with the Chief and local authorities should ensure that unwanted development is not encouraged.

- *Degradation of law and order, caused by migrants attracted to the area by job expectations.*

  The Chief expressed his strong concerns on this issue.

- *Potential clash of tribal and legal (government/state) laws.*

  This concern is related to the expectations of the Chief and his people from the project.

In order to continue to build a relationship with stakeholders and communicate ECV policy on social and environmental management to the public, ECV will maintain the public consultation process initiated at the start of the EIA. Meetings will be held 6 monthly or annually following a decision to proceed to project development.

The Mining Project and Local Communities

The location of the Lumwana mine and its components has implications on the local communities regarding:

- *Safety of local communities:* The open pits, mine dumps, haul roads, mine access roads, tailings storage facility, Lumwana East River diversion scheme, process plant area, workshops, water dams and contractor's facilities will be well secured and guarded by security personnel. The total footprint of these mine components is approximately 39 square kilometers. Potential hazards include inadvertent access by the public into mine areas, movement of heavy equipment and vehicles, drowning in dams, blasting, electric shock, operating machinery and drinking mine effluent.

  To mitigate the risk, ECV will implement a community safety awareness programme and erect warning signs in potential hazard areas to safeguard local communities. The plant site and workshops will be fenced off. Access to operational areas will be via a security gate. However, fencing off of the greater project area is considered impractical because of its size and the propensity for fences to be stolen, as is the experience at other mine sites in Zambia.

  It is expected that the layout of the mine and its components will restrict/prevent inadvertent access to most of the potentially hazardous areas.
- *Safety and security of company owned equipment*: All fixed company and contractor equipment will be fenced off and guarded by mine security.
- *Conservation & management of natural resources:* ECV will endeavour to conserve environmental resources within the mine surface area that have not been disturbed by mining operations and demonstrate active stewardship of the land and bio-diversity. This will involve the prevention and discouragement of further deforestation in accordance with ECV's Sustainability Policy.
- *Traditional right of way:* The mining project will impact on approximately a 12 km length of the Lumwana East River and present a physical barrier to the movement of people in the area. Exploration tracks have over time become established rights of way for people crossing the river and have opened up new areas for cultivation to the north of the immediate project area. ECV will liaise with the Chief and local community to establish an alternative safe access route passing to the west of the Malundwe open pit.
- *Employment*: Employment is a major expectation of the local people. ECV will develop an employment policy in which local people will be given priority, subject to ability and suitability. The company will strive to be an equal opportunity employer in all respects.
- *Mine Housing:* ECV will support the construction of the Lumwana Estate where all employees and contractors will be accommodated.
- ECV sees itself essentially as a project developer and mine operator. Accordingly, its main focus will be on the core business of mining and mineral processing. The Company's position in this respect will be communicated to the local communities to emphasise the fact that the company's relationship with the local communities will be based on practical assistance and not paternalistic support.

Environmental Quality

Mining activities have a potential to degrade the environment in such a way that the quality of the human environment is affected negatively. ECV will plan and conduct its project development in an environmentally responsible manner consistent with the principles of sustainable development.

The Company will minimise to the greatest extent possible any unnecessary disturbance to the environment including native flora, fauna, air, water, the natural landscape, sites of archaeological, historical, natural or scientific value and the interests and activities of all legitimate land users.

In this regard the Company will comply with Government Regulations and actively develop, implement and improve environmental standards consistent with Government regulations and guidelines, industry codes and public expectations.

Population Influx and Secondary Development

Development of the Lumwana Copper Project has the potential to encourage additional population influx and secondary development peripheral to or unrelated to the mineral activities. ECV will need to forestall unplanned development (or induced development) surrounding the mine site. In order to do this the Company will work with and support appropriate government departments and the Chief, to control 'secondary development' in the vicinity of the mine.

Increased Vehicular Road Traffic

Project construction and mine operations will result in a substantial increase in the volume of road traffic in the Lumwana area and on the T5 main road to Solwezi and Chingola. During the operational phase of the mine, 2 to 3 truck movements per hour are expected on the T5 road in addition to heavy traffic movement in and around the mine site. This will have potential road safety impacts on the local community. ECV will define and monitor vehicle standards and adherence to road traffic regulations in order to promote a safer working environment and prevent/minimise the occurrence of road accidents.

Local Culture and Customs

The mining project will have a negative impact on local customs and cultures of the local communities. Company employees will be drawn from all over Zambia and the world. ECV recognizes the importance of being sensitive to and preserving as far as possible the cultures, customs and values of the local peoples. To this end ECV will include local cultures and customs in its induction courses for employees and contractors, particularly non-Zambians.

Potential Increase in HIV/AIDS Infections

The project is likely to attract a large number of job seekers from outside the community. This population influx has the potential to increase the chances of the spread of HIV/AIDS infections in the area. HIV/AIDS is not just a public health problem; it is a major development crisis and will have implications on the operations of ECV. The company will implement an HIV/AIDS policy based on education and prevention, which will be communicated to all employees. In practice, community, church and education groups will be encouraged to support this initiative.

5.17.3 Post-Closure Impacts on Communities

Mine Closure Plan

A provisional mine reclamation plan has been developed (refer to Section 6.6). This plan includes:

- Possible extension of mine life through exploration (one third of the current resource is presently in the mining schedule);
- Possible extension of mine life through improved economics;
- Progressive rehabilitation and decommissioning of the mine site; and
- Proposal for the retention of some constructed facilities by the community, in particular the dams to be used for crop irrigation, aquaculture, leisure and wildlife tourism.

Proposals in the mine closure plan will be important in facilitating sustainable social development in Lumwana.

Sustainable Social Development in Lumwana

Sustainable development is about meeting the needs of current and future generations through integration of environmental protection, social advancement and economic prosperity. Since mining is a non-renewable resource industry with a finite lifespan, any use of sustainable development principles in reference to the community economic development must focus heavily on what occurs after the mine closes. The challenge therefore is to see that the mining sector contributes in a more lasting way.

The presence of high paying jobs, infrastructure development, and community improvements in the areas of education, health and recreation are important for any community. However, the focus must remain on the long-term, what happens when there are no more paying mining jobs, and how will community infrastructure be maintained? Will future generations have the same opportunities and potential?

Importance must be placed upon three areas in developing a sustainable social development plan for communities in Lumwana. These are:

1. Community and social development;
2. Economic diversification and development; and
3. Continued proactive mining exploration and extraction support.

To further reduce economic dependency, ECV will promote the concept that any new infrastructure and off-site investment developed for the mine also be used for other economic generating activities i.e. electrification of the Lumwana area and water supply from dams.

Community and Social Development

In order to develop an atmosphere that is favourable to economic diversification and development, focus must be placed upon community and social development. The primary factor in community and social development is education. A community that has a highly trained and skilled work force can adapt more readily to a changing economy and adopt new trends in technology and development. Not only does education provide long-term benefits to the community and region, but also short-term benefits are available to existing industries in having a qualified and skilled labour pool at their disposal. In addition, further improvement in the areas of health, recreation and other quality of life issues must occur.

Economic Development and Diversification

Any sustainable development structure must focus on the development of a plan for the transition to a post-mining economy. The concepts of this plan should not only focus on long-term eventualities and prospects, but also on immediate employable strategies, such as ensuring that any new infrastructure developed for mining purposes also be usable for other economic generating activities.

Lessons from the Copperbelt mining experience make economic diversification more imperative for any mining development activity in Lumwana. The fundamental purpose of diversification will be to develop an economic base providing a broad spectrum of employment beyond mining, which is able to sustain a community.

In this regard ECV will be supportive of local businesses and the generation of new businesses. This support will be through implementation of local procurement practices and local employment and training strategies.

Economic development and diversification does not occur in a vacuum and is inseparably entwined with community, social and human development. A sustainable development framework should include provisions and funding by government to assist the development of economic diversification strategies. In this regard, ECV will actively engage relevant government ministries and departments, NGO's and donor agencies to encourage the development of an Economic Diversification and Development Plan based on diversification from mining and its related activities.

Pro-active Mining Exploration and Extraction Support

ECV with the assistance of the Government of Zambia will develop strategies to extend the life of Lumwana mine beyond 18 years and promote new developments and investments. The Company will engage the government on issues related to (for example) taxation in order to attract new investment to the area and create a favourable climate for future development opportunities. Dialogue between the mining industry, government and utilities such as the Zambia Electricity Supply Company (ZESCO) on energy costs and energy saving programmes to achieve a reduction in overall operational costs is one example of what can be done to extend the long-term viability of the mining industry in North-western Province.

5.17.4 Conclusion

There can be no doubt that a large mining project in Lumwana will have significant socio-cultural and economic impacts on the local population. Chief among these are the employment opportunities that will arise from the project. Other potential social impacts include the influx of outsiders into the areas seeking employment. This may result in unplanned settlements in the area with many associated problems. The company needs to engage local leadership in order to maximise the positive benefits of the project to the community and reduce negative effects.

As part of the ongoing planning process, consultations are needed with the community and other interested and affected parties, to ascertain their concerns and also their vision for the future. In developing the sustainable development framework for Lumwana, it will be important to maintain a sense of collaboration and cooperation among the various stakeholders.

ECV's Social Management Plan, which specifies management actions to mitigate project socio-cultural and economic impacts, is presented in Section 5.5.

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6. SUSTAINABILITY MANAGEMENT PLANS

6.1 Introduction

Under the broad banner of sustainability, management plans have been prepared for five key areas:

- Environmental Management Plan;
- Environmental Monitoring Plan;
- Occupational Health and Safety Management Plan;
- Social Management Plan; and
- Reclamation and Closure Management Plan.

Whilst implementation of these plans is functionally part of the responsibility of all Managers on site, the Health, Safety and Environment (HSE) Manager is responsible for ensuring compliance to and implementation of the plans.

The HSE Manager reports directly to the Managing Director and will be supported by a range of technical and non-technical specialists in ensuring the requirements are completed.

Key components of ensuring activities are completed are:

- Monthly meetings with the Managing Director and all Heads of Department, focussing on the core issues of HSE and social aspects;
- Monthly reports for internal management and monitoring purposes;
- Annual Report for regulatory agencies (appropriate to meet financial institution needs);
- A schedule of audits and inspections;
- HSE Management System (Section 5.2)

6.2 Environmental Management Plan

A key component of the EIA is the Environmental Management Plan (EMP). This has been prepared and is attached as Appendix E.

The intent of the EMP is to ensure that the environmental objectives of the project are met.

The EMP is based on the various components of the Project and contains detailed management objectives and prescriptions for the various aspects and issues of each particular area.

The various Project components are:

- Open Pits;
- Waste Rock Dumps;
- Plant area, ROM Pad and processing facilities;
- Tailings Storage Facility;
- Lumwana East River Diversion system;
- Workshop area;
- Transport infrastructure;
- Waste management;
- Materials Handling and Storage;

The EMP specifies:

- Aspect/Issue – what needs to be managed;
- Objective – why it needs to be managed; and
- Management Action – how it will be managed.

Each management action is numbered. The total number of management actions is 117. Where appropriate, provisional timings for management actions are also given. Year -1 denotes the beginning of the construction period.

There are further procedures and management plans to be developed, key elements discussed in the EMP include:

- Emergency Response Plan;
- Waste Management Strategy;
- Clearance Procedures;
- Materials Handling Procedures.

Prior to the commencement of relevant activities, these will be in place.

6.3 Environmental Monitoring Plan

ECV will implement an environmental monitoring plan in and around the operational area to monitor environmental performance and compliance with statutory environmental regulations. Environmental monitoring will provide the information for periodic review and alteration of the EMP as necessary ensuring that environmental protection is optimised at all stages of the development. This will ensure that undesirable environmental impacts are detected early and remedied effectively. It will also demonstrate compliance with regulatory requirements.

Fro the first five years, mining activities are focussed on the Malundwe area, as such; the monitoring program is also focussed in this area. During this first five years, baseline monitoring will continue to be undertaken when required around the Chimiwungo area to ensure and adequate database of information prior to disturbance and activities in this area. This will be discussed through the annual update of the EIA

At ECV, the monitoring program will comprise the following aspects:

- Water (ground and surface);
- Land;
- Biology (aquatic and terrestrial);
- Air and noise (includes meteorological conditions);
- Processes and wastes; and
- People and communities, including heritage values.

Environmental monitoring data will be maintained in an electronic data base and Geographical Information system (GIS). This will be the key management tool to monitor historical and current environmental performance as well as environmental compliance.

6.4 Health and Safety Management Plan

ECV will implement internationally accepted occupational health and safety standards and procedures throughout its operations to create a safe workplace thereby protecting its employees from accidents and sickness. Key OHS measures to be implemented are outlined in the following sections.

6.4.1 Workplace Air Quality

In addition to the air quality monitoring outlined in Appendix F, good ventilation will be provided in the workplace. The condition of protective respiratory equipment and air quality monitoring equipment will be routinely checked and maintained.

Protective respiratory equipment will be provided to all employees when the exposure levels for welding fumes, solvents and other substances present in the workplace exceed statutory limits or adopted standards. Respiratory protection will be worn at all times in dusty environments and when air monitoring data, indicates that respiratory protection is required.

Dust masks will be issued to all employees working in areas where particulates (inert or nuisance dusts) may exceed the statutory limit of 50 mg/m^3.

Health and safety personnel will conduct routine inspections to ensure the appropriate respiratory protection equipment is in good working condition and being used correctly.

6.4.2 Workplace Noise

All plant equipment (belonging to the mine and contractor) will be subject to a routine maintenance programme to ensure it is in good working order and to minimise noise levels.

Where it is practicable and feasible to do so, ECV will install sound-insulation and control rooms to reduce the average noise level exposure in normal work areas.

ECV will adopt the international standard of 85 decibels (dB) for exposure of its employees to noise over a 12-hour shift. Employees will wear appropriate ear protection in workplaces where noise levels exceed 85 dB.

Health and safety personnel will monitor the use of ear protection on the mine.

6.4.3 Working in Confined Spaces

Entering into confined spaces such as tanks, vessels, sumps and excavations to carry out inspection, repair and/or maintenance can expose workers to the danger of toxic, flammable or explosive gases, or lack of oxygen. These spaces must be tested for the presence of gases or lack of oxygen and adequate ventilation provided before and during occupancy. Employees working in confined spaces, which may become contaminated or deficient in air must wear appropriate air-supplied respirators. Suitably equipped observers must be stationed outside of confined spaces to provide emergency assistance if required to people working inside.

6.4.4 Handling and Storage of Hazardous Materials

All hazardous (reactive, radioactive, corrosive and toxic) materials or substances will be stored in clearly labelled containers or vessels. Fire protection systems and secondary containment will be provided to storage areas to prevent fires or the release of hazardous materials into the environment. Storage and handling of hazardous materials will be carried out in accordance with Zambian Regulations and the Company's Materials Handling Procedures as outlined in the Environmental Management Plan.

6.4.5 Employee Health - General

Pre-employment and periodic medical examinations will be conducted on all mine employees. As a minimum, the baseline medical examination would include the following:

- A short medical history of the employee and his family history;
- Full occupational history of the employee;
- Signature of the employee to state that the above information is accurate and correct;
- Examination of:

- o Weight
- o Height
- o Blood pressure
- o Pulse
- o Urine test
- o Eye Test (Snellen Chart)
- o Chest X-ray (large 35 cm x 43 cm)
- o Audiometry test - physical and visual inspection of both ears
- o Lung function
- o Cardio-respiratory examination (general physical examination)

A Doctor and trained staff will perform the employee medical examinations.

ECV will provide well-equipped sanitary facilities for its employees. Workers will be encouraged to wash or shower frequently, particularly those employees exposed to dust, chemicals or pathogens.

Workers in areas of high temperature and/or humidity will be allowed to take frequent breaks away from these areas.

The Company's Chief Medical Officer will keep a record of employee medical examinations, specific surveillance records and medical history.

6.4.6 Radiation Exposure and Uranium Toxicity

Specific surveillance programmes will be instituted for workers potentially exposed to toxic or radioactive materials.

ECV is proposing to adopt the International Commission for Radiological Protection (ICRP) limits for radiation exposure. The ICRP recommends that the additional radiation dose above natural background and excluding medical exposure should be limited to 1 mSv/a for members of the public and 20 mSv/a averaged over 5 years for radiation workers who are required to work under closely monitored conditions. The average natural background radiation exposure at Lumwana has been calculated as 3.96 mSv/a from baseline radiation measurements (refer to Section 3.12 - Background Radiation Survey).

ECV will monitor radiation doses received by workers at the crusher plant and tailings storage facility. In practice, workers exposed to radiation will wear dosimeter badges. Advice will be sought from the Radiation Board of Zambia on employee radiation dose monitoring. Records of radiation doses received by workers will be submitted to the Mines Safety Department, Environmental Council of Zambia and the Radiation Board of Zambia every 6 months.

6.4.7 Employee Safety - General

Conveyors and similar machinery will be provided with a means of stopping them at any point. Guards will be fitted to all drive belts, pulley, gears and other moving parts to protect workers. Above ground platforms, walkways, gantries, scaffolds, stairways and ramps will be equipped with handrails and non-slip surfaces. All electrical equipment will be grounded, well insulated and conform to applicable codes. For the same safety reasons, mobile equipment working on the EW operating floor will not be grounded. Mine employees will be provided with hardhats, safety boots, overalls (acid proofed where required), ear and eye protection, dust masks and gloves as appropriate. Plant site piping will be colour coded for acid, water, compressed air, process solution etc.

The Mining Explosives Regulations governing the safe storage, handling and transport of explosives to and in and around the mine will be strictly enforced. Only qualified and certified personnel will carry out blasting operations.

Hazard signs will be erected or posted around the plant and mine site to warn employees and contractors of potential dangers.

Contact telephone numbers of persons and services to be notified in the event of an emergency will be posted on all notice boards.

6.4.8 Training

All personnel will receive the general induction prior to operating on site as well as an area specific induction. This induction will incorporate information that is common to all personnel such as:

- Personal Protective Equipment (PPE);
- Signage;
- Work permits;
- Statutory requirements;
- General health issues;
- Accident prevention
- Accident/Incident reporting

Additional training will be also provided to personnel where it is identified that it is required. This may include:

- Use of chemicals;
- Safe lifting practices;
- Working at heights;
- Confined space
- Isolations;
- First Aid;
- Emergency Response;

6.4.9 Emergency Fire and Rescue Services

Lumwana mine site is relatively remote from urban centres the closest being Solwezi, the provincial capital (95 km distance). Whilst a provincial fire station will be incorporated in the Lumwana Estate, the mine will be equipped with its own fire tender and light fire tender utility vehicle. The fire fighting team will be made up of volunteers who will receive external professional training in fire fighting and combine their normal mine duties with the role of firemen. A volunteer mine rescue team will be established to assist the fire fighting services. This team will be provided with specialist training.

6.4.10 Health & Safety Records

In addition to the medical records kept by the Chief Medical Officer, the HSE Manager will maintain records, including but not limited to monitoring data, accidents and occupational illnesses, and spills, fires and other emergencies. This information will be used to evaluate and improve the effectiveness of the health and safety management programs. Health and safety statistics will be reported at the monthly HSE Management Meetings and included in the quarterly and annual mine reports.

6.5 Social Management Plan

The principal objectives of ECV's Social Management Plan (SMP) are to:

- Maximise local and provincial employment and business opportunities;

- Encourage diversification and movement away from the historical dependence of Zambian business on the mining sector;
- Assist community development by constructing a school, clinic and recreation facilities;
- Promote sustainable businesses that will survive the eventual closure of Lumwana mine.
- Explain ECV policies on environmental issues to the community and public at large, via the public consultation process.

The SMP is presented in detail in Appendix G. The plan specifies the project socio-cultural and economic issues that need to be managed by ECV, objectives and management measures. The SMP aspects and issues that require management are summarised in Table 6-1.

Table 6-1: SMP Aspects and Issues that Require Management

Aspect No.	Aspect Description	Issue That Requires Management
1.	Employment, Conditions of Service & Retrenchment.	• Maximising local employment and economic opportunities during mine operations.
2.	Local Economic Development Plan.	• Local procurement. • Economic diversification.
3.	Land Use and Settlement.	• Local knowledge of the mine surface area and the company's land use and settlement policy. • Land utilisation outside hazardous areas. • Use of mine surface area water / water bodies.
4.	Education and Training.	• Mine support to the local government school.
5.	Healthcare.	• Operation of ECV plant site clinic.
6.	Sports and Recreation Facilities.	• Mine clubs and recreation activities.
7.	Community Management.	• Capacity of communities to manage resources.
8.	Public Consultation.	• Consultation with the public.
9.	Decommissioning and Closure Plan.	• Mine closure.

A total of 32 management actions are proposed together with the proposed timing of each action. The SMP is structured to facilitate future auditing of social performance against management actions.

6.6 Mine Reclamation Plan

ECV will implement a mine reclamation plan over the projected 18-year life of Lumwana mine. The plan will focus on the reclamation of the open pits, waste rock dumps, the TSF, mill and processing facilities, river diversion and associated infrastructure. The main objectives of the plan will be to:

- Return the land to conditions capable of supporting the former land use or where this is not practical, nor feasible, an alternative sustainable land use;
- Prevent potential significant adverse effects on adjacent water resources.
- Return the land to conditions capable of supporting the former land use or where this is not practical, nor feasible, an alternative sustainable land use;
- Prevent potential significant adverse effects on adjacent water resources.

Mine reclamation activities will be progressive leaving minimal works outstanding at mine closure except for plant site decommissioning.

ECV will maintain a land disturbed land register (Section 5.5) to monitor land cleared versus land rehabilitated with the aim of having a ration that improves over time. Aerial photography, or similar, will be used to annually maintain the database and provide an accurate snapshot of disturbance and visible impacts.

6.6.1 Mine Reclamation Plan

The Lumwana Mine Reclamation Plan is described by mine component.

Malundwe Main and South East Open Pits

The Malundwe open pit ore reserves will be exhausted in project year 5. At this time mine dewatering will cease and the pits will flood by natural recharge from aquifers, direct precipitation, runoff from waste rock dump and inflow from the Lumwana East River, which will be re-directed into the pits from below the Lumwana dam spillway. The Malundwe south east pit will fill and overflow into Malundwe main pit, which will in turn overflow into the original Lumwana East River. Baseline groundwater analyses and geochemical characterisation of sulphidic internal waste and Malundwe tailings indicate that the water in the disused pits will be of good quality. The pit water should not adversely affect the quality of adjacent watercourses.

Post closure, the flooded pits will have several potential uses, all of which are sustainable. These potential post closure uses are:

- Agriculture / irrigation;
- Tourism / recreation;
  - Aquatic nature reserve
  - Camping and fishing
  - Sailing
- Fish farming / aqua-culture

Slope stability studies will be conducted at close to closure to ensure that the pit high walls are stable and there is no significant risk of failure.

Contractors employed by ECV will dismantle and remove from site all buildings, sewage systems, concrete foundations, workshops, fuel storage facilities, electrical and mechanical equipment, and materials, which cannot be put to sustainable use. Concrete, bricks and mortar will be disposed of in the Malundwe open pit. The contractor will reinstate affected areas to an acceptable state. .

Chimiwungo Main, South and East Open Pits

At closure, mine dewatering will cease and the pits will flood through natural recharge, direct precipitation and inflow from local streams. The Chimiwungo South and Main pits are likely to overflow into the Chimiwungo Stream during the wet season. The Chimiwungo East pit is unlikely to spill because there is no natural watercourse flowing into it. Baseline groundwater analysis indicates that the water in the disused pits will be of good quality. The pit water should not adversely affect the quality of adjacent watercourses.

Potential post closure land uses are the same as those for the Malundwe open pits and similar slope stability checks will be performed to ensure long-term high wall stability.

Waste Rock Dumps

The Malundwe and Chimiwungo waste rock dumps will be constructed with mine closure in mind. Reclamation of mine waste rock dumps will be successfully achieved by combining good construction practice according to engineering design with progressive re-vegetation of dump slopes and upper surfaces. To prevent slope erosion, which could potentially affect the quality of adjacent watercourses; dump walls will be terraced with 20 metre berms, inter-berm slope angles of 23° and overall slope angles not exceeding 20°. Dump walls will be further fortified by placing higher strength waste materials close to the walls and weaker waste materials at the centre of the dump. This diligent approach to dump construction and management will eliminate any potential requirement for high cost slope re-profiling at closure and long-term post closure monitoring. The overall 20° slope angle will allow the dumps to merge with the surrounding topography with minimal obtrusiveness once reclamation is compete.

The key to rehabilitation of the dumps is good planning and progressive rehabilitation; the lower parts of the dumps formed at the beginning of mining will be used for trials to ascertain stabilities and determine practical solutions for the area to allow areas to be contoured as operations occur and then rehabilitation with native vegetation as soon as possible.

The objective of the dumps re-vegetation programme will be to encourage development of a self-sustaining woodland type ecosystem similar to the original land use in so far as it is practicable and feasible to do so.

A soil improvement programme will be implemented as the dumps are raised, and terraces, inter-berm slopes and final upper surfaces are established. Soil improvement will be achieved using stockpiled organic matter and topsoil, prepared organic mulches and fertiliser when required. Advice will be sought from the Provincial Forestry Department in Solwezi regarding the species and diversity of vegetation to be established on the dumps.

Lumwana TSF

Reclamation of the Lumwana valley tailings storage facility (TSF) is not likely to begin until around year 15 of the Project. Small areas will be used for trial areas to test cover materials and vegetation types.

Post closure, the Lumwana East River will continue to be diverted around the tailings.

A similar re-vegetation strategy to that proposed for the waste rock dumps will be applied to exposed tailings. A soil improvement programme will be carried out using stockpiled organic matter and topsoil, prepared organic mulches and fertilizer. Indigenous plants, shrubs and trees will be transplanted from the nursery to the dumps. However, due to the relatively coarse and likely loose nature of the insitu Lumwana tailings, it is likely that tall or mature trees could fall under their own weight, or as a result of high winds. Re-vegetation will therefore focus on establishing a grassland and acacia woodland capable of supporting small mammals and birds common to the area.

Lumwana Water Dam

A self-sustaining aquatic wetland/shallow lake ecosystem is proposed for the Lumwana Dam and peripheral wetlands. It is expected that aquatic flora and fauna originating upstream of the dam will rapidly invade and colonise the dam area.

The health of the aquatic animals and plants living in the dam will be monitored at 5-year intervals over a 15-year period. Samples of animal and plant life will be analysed for metal concentrations.

ROM Pad, Mill and Processing Facilities (Plant Site)

All ore on the ROM pad will be processed or removed to a defined location in one of the Chimiwungo pit. The area will be re-profiled to establish the natural drainage pattern.

Decommissioning of the mill and all processing facilities will take place at mine closure in project year 18.

A survey of mine workshops, stores buildings, infrastructure and mine offices in the plant area will be conducted prior to mine closure. Alternative uses will be considered if they are consistent with the final land use and with approval from regulatory agencies use. Otherwise all will be dismantled and disposed of, either by sale or burial within one of the Chimiwungo pits.

The following plant and equipment dismantling and disposal practices will be applied to the crusher plant, mill and concentrator:

1. Removal of all brick buildings;
2. Breaking out and removal of all concrete foundations;
3. Removal of steel frame buildings;
4. Demolish reinforced concrete structures and dispose of on site;
5. Remove HDPE liners and backfill all process ponds;
6. Remove electrical equipment, pumps, motors and other fixed equipment;
7. Remove all fuel storage tanks;
8. Cut up and remove steel tanks and vessels;
9. Remove all pipelines;
10. Dig up and remove all below ground electricity cables;
11. Remove conveyor belting;
12. Remove all mechanical equipment;
13. Materials handling areas will be cleared of all raw materials;
14. General site clean-up;
15. Site levelling and re-profiling to re-establishment the natural drainage pattern across the site;
16. Re-vegetation with indigenous grasses and trees.

All concrete foundations will be broken out to a depth of 500 mm below existing ground level and disposed of in the Malundwe open pit together with bricks and mortar and concrete debris from the demolition of plant buildings.

Scrap materials and equipment will be sorted and sold to the local community, businesses and scrap metal merchants. ECV will remove all equipment and materials that cannot be reused, recycled or sold, to an ECZ approved non-hazardous disposal site.

A soil survey will be conducted at closure to identify any areas of inorganic and/or organic soil contamination. The soil survey will involve a programme of test pitting to a depth of 500 mm, soil sampling and analysis. The number and location of test pits will be based on a site walkover / inspection at closure to identify potentially contaminated soils. A deeper soil investigation may be necessary at specific locations (pollution sources) depending on the findings of the near surface soil survey.

Inorganic soil contamination including copper, cobalt, uranium and sulphate will be treated on-site using reduction of solubility methods to reduce the concentration of contaminants in the soil solution. This may be achieved by adding lime to stabilise the soil pH between 5.3 and 6.5, the application of organic matter (decaying vegetation) and/or incorporation of safe sewage waste to the soil.

Localised organic soil contamination resulting from the accidental spill of diesel and oil will either be treated by the removal from site to an ECZ approved hazardous disposal site or processing of contaminated soil on site to reduce extractable concentrations to an acceptable level (<300 mg/kg). The appropriate treatment in the Zambian context for a larger contaminated area is bio-degradation i.e. land farming.

Soil contaminated with chemical reagents will be removed to an ECZ approved hazardous disposal site.

The ROM pad and plant area will be re-vegetated following, dismantling of the process plant, removal from site of all equipment and materials, treatment or removal of contaminated soil (if any) and re-profiling of the area to re-establish natural drainage patterns. A soil improvement program will be carried out using stockpiled organic matter and topsoil, prepared organic mulches and fertiliser. Indigenous plants, shrubs and trees will be planted.

6.6.2 Mine Reclamation Schedule

The proposed mine reclamation schedule is shown in Table 6-2 below. The reclamation commencement and completion timing is only approximate at this time and will be subject to change, depending on the development or extension of mine operations.

Table 6-2: Lumwana Mine Reclamation Schedule (18 year mine life)

Item No.	Mine Component / Description	Reclamation Schedule	
		Commencement	Completion
1.	Open Pits:		
	Malundwe Main and South East Pits	Year 6	Year 7
	Chimiwungo Main, South and East Pits	Year 18	Year 19
2.	Waste rock dumps:*		
	Malundwe	Year 5	Year 7
	Chimiwungo	Year 15	Year 19
3.	Lumwana Valley TSF.	Year 15	Year 19
4.	ROM Pad and Plant Area.	Year 18	Year 19

* Schedule relates to waste rock dump reclamation activities to be done after the cessation of dumping. However, reclamation of dump slopes (re-vegetation) will be done progressively as the dump is raised.

6.6.3 Post Closure Environmental Inspection, Monitoring & Reporting

A programme of post closure environmental inspection and monitoring will be implemented from year 19, to assess the success of mine reclamation and verify that the disused open pits, waste rock dumps, TSF and plant area are not adversely affecting the quality of adjacent watercourses and do not present a potential health risk and/or danger to the public.

Post Closure Environmental Inspection

ECV proposes that site environmental inspections be conducted annually for the first 5 years following closure. These inspections will be conducted in October of each year prior to the onset of the rains and will focus on the following:

- Evidence of open pit high wall instability;
- Signs of erosion on waste rock dump walls and upper surfaces;
- Success of establishing an indigenous vegetation cover on TSF, waste rock dump, ROM pad and plant area;
- Condition, performance and operation of the TSF spillway and drainage channel;
- Structural integrity of Lumwana Dam wall;
- Evidence of any activity by the general public or persons unknown that may adversely affect the stability of disused mine structures, pose a danger to the community or possibly result in environmental degradation; and
- Condition of site access roads, bridges and culverts.

Consultations will be held with local community leaders to listen to and record any issues of concern pertaining to the closed mine site.

Post Closure Environmental Monitoring

ECV proposes that post closure environmental monitoring be conducted 6 monthly for the first 2 years after closure to establish seasonal variations and then annually in years 3, 4 and 5. 6

monthly monitoring will be done pre and post wet season (October and April). Annual monitoring will be conducted in October.

Post closure environmental monitoring will include the following:

- Surface water sampling across the mine site;
- Groundwater sampling at the plant area; and
- Measurement of radon gas concentration in air on and adjacent to and exposed tailings in the Lumwana valley TSF.

Surface water samples will be collected at the following locations:

- Lumwana water dam spillway;
- Chimiwungo Stream above the confluence with the Lumwana Dam spillway discharge;
- TSF seepage and flow rate through waste rock dump;
- Drainage from the former plant area;
- Drainage from the former ROM pad area;
- Malundwe main pit;
- Malundwe east pit;
- Chimiwungo south pit;
- Chimiwungo east pit;
- Chimiwungo main pit; and
- ECZ licensed discharge point (SW2).

The surface water samples will be submitted to an accredited laboratory and analysed for the key parameters pH, EC, TSS, TDS, Cu, Co, As, Mn, U and radium-226.

Groundwater samples will be collected from appropriate groundwater monitoring bores; 3 located to the north of the former mine plant area and 1 located adjacent to surface water monitoring site SW2. The groundwater samples will be submitted to an accredited laboratory and analysed for the key parameters pH, EC, TDS, SO_4, Cu, Co, As, Mn, U and radium-226. The radon gas concentration in air at the Lumwana TSF will be measured on and peripheral to any exposed tailings.

Post Closure Environmental Reporting

The consultant will produce an annual post closure environmental monitoring report for ECV, which will be circulated to all relevant stakeholders and the ECZ. The report will present the findings of the mine site inspection/walk-over and results of the environmental monitoring programme. Where reclamation activities have not attained the desired result, further work will be undertaken to ensure completion criteria are attained.

It is expected that annual post closure inspections and environmental monitoring will cease in year 5. Final mine site inspection and environmental monitoring will be concluded in year 10.

6.7 Mine Reclamation Costs

The following costs have been estimated to carry out mine site reclamation and conduct post closure site inspections and environmental monitoring at Lumwana.

6.7.1 Mine Site Reclamation Costs

It is estimated that over 98% of mine site reclamation costs will be associated with the following three activities:

- Re-vegetation of the mine waste rock dumps;
- Revegetation of the TSF; and
- Decommissioning and closure of the mine plant and workshop site.

Reclamation rates in US$/ha have been estimated for each of the above mine site reclamation tasks. Total mine site reclamation costs were then calculated.

Estimate of cost to re-vegetate the upper surface of the waste rock dumps and TSF

The estimated unit rate in US$/ha to re-vegetate the upper surfaces of waste rock dumps and the TSF based on Zambian input prices and labour rates is US$1,323.25/ha. The cost breakdown by activity is given in Table 6-3.

The total upper surface area of the Lumwana waste rock dumps is approximately 1,285 ha. The estimated re-vegetation cost is US$1,323.25 x 1285 ha = US$1,700,376.

A provisional figure of US$1,058,600 has been allowed for the reclamation of the Lumwana valley and. This is for capping of tailings and re-vegetation with indigenous grasses and acacia.

Re-vegetation will be carried out in the wet season between November and April each year.

Table 6-3: Unit Rate to Re-vegetate the Upper Surface of Waste Rock Dumps

Item No.	Activity	Unit	Qty	Rate US$	Cost US$
1.	**Agricultural / Chemical Inputs**				
1a.	Provide agricultural crushed limestone	t/ha	5	33.00	165.00
1b.	Provide 2:3:2 fertilizer	t/ha	0.75	417.00	312.75
1c.	Provide phosphate fertilizer	t/ha	0.5	332.00	166.00
1d.	Provide organic mulch/stockpiled topsoil	t/ha	1.5	100.00	150.00
	Sub total				**$793.75**
2.	**Mechanical Equipment**				
2a.	Plough soil	ha	1	16.50	16.50
2b.	Disc soil	ha	1	13.00	13.00
2c.	Apply crushed lime	ha	1	10.00	10.00
2d.	Apply fertilizer	ha	1	4.00	4.00
2e	Transport (4 x 2 pick-up)	days	6	25.00	150.00
	Sub total				**$193.50**
3.	**Labour**				
3a.	Transplant indigenous grasses, shrubs and saplings (4 labourers)	days	24	8.00	192.00
3b.	Place organic mulch (1 labourer)	days	6	8.00	48.00
3c.	Works supervisor	days	6	16.00	96.00
	Sub total				**$336.00**
TOTAL RE-VEGETATION UNIT RATE PER HECTARE					**US$1,323.25**

Estimate of cost to re-vegetate waste rock dump slopes and berms

The estimated unit rate US$/ha to re-vegetate the sidewalls (inter-berm slopes of 20 degrees) of the mine waste rock dumps based on Zambian input prices and labour rate is US$967.00/ha. The cost breakdown by activity is shown in Table 6-4.

Table 6-4: Unit Rate to Re-vegetation the Waste Rock Dumps Side-walls

Item No.	Activity	Unit	Qty	Rate US$	Cost US$
1.	**Agricultural / Chemical Inputs**				
1a.	Provide agricultural crushed limestone	t/ha	5	33.00	165.00
1b.	Provide phosphate fertilizer	t/ha	0.5	332.00	166.00
1c.	Provide organic mulch/stockpiled topsoil	t/ha	1.5	100.00	150.00
	Sub total				**$481.00**
2.	**Mechanical Equipment**				
2a.	Transport (4 x 2 pick-up)	days	6	25.00	150.00
	Sub total				**$150.00**
3.	**Labour**				
3a.	Crushed lime application by hand (1 labourer)	days	6	8.00	48.00
3b.	Fertilizer application by hand (1 labourer)	days	2	8.00	16.00
3c.	Place organic mulch (1 labourer)	days	10	8.00	80.00
3d.	Transplant indigenous grasses, shrubs and saplings (4 labourers)	days	24	8.00	192.00
3e.	Works supervisor	days	6	16.00	96.00
	Sub total				**$432.00**
TOTAL RE-VEGETATION UNIT RATE PER HECTARE					**US$1,063.00**

The total surface area of the sidewalls (berms and inter-berm slopes) on the Lumwana waste rock dumps is approximately 578 ha. The estimated re-vegetation cost is US$1,063.00 x 650 ha = US$690,950.

Re-vegetation will be done in the wet season between November and April.

Estimate of decommissioning and closure costs for Lumwana mine plant site

The Lumwana plant site dismantling and disposal unit rate in US$/ha is based on the results of a detailed costing exercise undertaken at ZCCM's Copperbelt mines by SRK Consultants and African Mining Consultants in 1997 during preparation of mine Environmental Impact Statements for each of the ZCCM mines (World Bank Funded Project). Dismantling and disposal activities include items 1 - 13 described in Section 6.6.1. - Mine Reclamation Plan.

These costs will be updated annually from year 1 onwards to ensure reclamation costs are realistic.

The exercise involved a survey of each of the mine plant sites to identify all dismantling tasks. Labour and plant equipment requirements were then determined and unit rates for each task calculated. A detailed log / description of all plant site buildings, structures and equipment (including estimate of quantity of construction materials) was compiled and the unit rates for dismantling and disposal tasks applied to each item on the log. The approach used was thorough and methodical and the costs calculated are considered to be a good indication of the likely cost to be incurred during dismantling and disposal of process plant and equipment at the Lumwana plant site.

Plant site dismantling and disposal unit rates (US$/ha) calculated for the Nkana, Chambishi, Nchanga, Konkola, Mufulira and Luanshya copper mines (1997 EIS) are shown in Table 6-5.

At the relatively new Chambishi mine (1960's) the open spaces between buildings and plant are reflected in a lower plant site dismantling and disposal unit rate, while the high density of buildings and plant at the older Nkana mine (1930's) results in a significantly higher plant site dismantling and disposal unit rate.

Plant site dismantling and disposal unit rates at Lumwana are likely to be similar to those of Chambishi and Konkola mines. The mean dismantling and disposal rate for these mines is US$45,163/ha. Allowing for an annual inflation rate of 1.5%/yr between 1997 and 2003 the estimated decommissioning and disposal unit rate for the Lumwana plant site is US$49,943/ha.

Table 6-5: ZCCM Plant Site Dismantling & Disposal Unit Rates, 1997 EIS's

Mine Plant Site	Dismantling & Disposal Unit Cost (US$/ha)
Nkana Mine*	$103,571
Chambishi Mine**	$39,482
Nchanga Mine	$59,895
Konkola Mine	$50,844
Mufulira Mina	$57,333
Luanshya Mine	$55,286

* *relatively old mine and high density of plant/buildings across mine site*
** *relatively new mine and low density of plant/buildings across mine site*

The approximate footprint of process plant and equipment at Lumwana is 31 ha. The estimated plant dismantling and disposal cost is US$49,943 x 31 ha = US$1,548,233. It is assumed that plant site stores, workshops and office buildings will be sold off and not dismantled.

A soil contamination survey will be conducted following the dismantling and disposal of process plant and equipment. It is estimated that this task will cost US$15,500 to complete. A sum of US$108,500 (US$3,500/ha) is included in the decommissioning and closure cost for the clean up of any contaminated soils present.

The estimated unit rate for plant site grading and re-profiling is US$9,000/ha. This figure is based on local earthworks rates of US$3.00/cu.m and an average re-profiling depth of 300 mm. The estimated cost of plant site grading and re-profiling is US$9,000 x 31 = US$279,000.

The estimated unit rate US$/ha to re-vegetate the mine plant area based on Zambian input prices and labour rate is US$1,036.60/ha. The breakdown of costs by activity is shown in Table 6-6.

The area of the plant site requiring re-vegetation is approximately 31 ha. The estimated cost of plant site re-vegetation is US$1,036 x 31 ha = US$32,116.

Re-vegetation will be carried out in the wet season between November and April.

The total Lumwana plant site decommissioning and closure cost estimate is US$1,983,339. The cost breakdown is summarised in Table 6-7. Some of this cost will be offset by revenue from the sale of plant equipment and scrap materials.

Lumwana Mine Site Reclamation Cost Estimate

The total Lumwana mine site reclamation cost including a 15% contingency is US$6,248,255. The cost breakdown is summarised in Table 6-8.

Table 6-6: Unit Rate to Re-vegetation the Mine Plant Area

Item No.	Activity	Unit	Qty	Rate US$	Cost US$
1.	**Agricultural / Chemical Inputs**				
1a.	Provide agricultural crushed limestone	t/ha	3	33.00	.00
1b.	Provide 2:3:2 fertilizer	t/ha	0.5	417.00	208.50
1c.	Provide phosphate fertilizer	t/ha	0.3	332.00	99.60
1d.	Provide organic mulch/stockpiled topsoil	t/ha	1.0	100.00	100.00
	Sub total				**$507.10**
2.	**Mechanical Equipment**				
2a.	Plough soil	ha	1		16.50
2b.	Disc soil	ha	1	16.50	13.00
2c.	Apply crushed lime	ha	1	13.00	10.00
2d.	Apply fertilizer	ha	1	10.00	4.00
2e	Transport (4 x 2 pick-up)	days	6	4.00	150.00
	Sub total			25.00	**$193.50**
3.	**Labour**				
3a.	Transplant indigenous grasses, shrubs and saplings (4 labourers)	days	24	8.00	192.00
3b.	Place organic mulch (1 labourer)	days	6		48.00
3c.	Works supervisor	days	6	8.00	96.00
	Sub total			16.00	**$336.00**
TOTAL RE-VEGETATION UNIT RATE PER HECTARE					**US$1,036.60**

Table 6-7: Lumwana Plant Site Decommissioning and Closure Cost

Item No.	Decommissioning and Closure Activity	Area ha.	Rate US$	Cost US$
1.	Dismantling and disposal of plant & equipment	31	49,943	1,548,223
2.	Soil contamination survey	31	500	15,500
3.	Treatment of contaminated soils	31	3,500	108,500
4.	Site grading & re-profiling (includes ROM pad)	31	9,000	279,000
5.	Re-vegetation (includes ROM pad)	31	1,036	32,116
Total Cost				**US$1,983,339**

Table 6-8: Lumwana Mine Site Reclamation Cost

Item No.	Reclamation Activity	Reclamation Cost US$
1.	Reclamation of tailings storage facilities	1,058,600
2.	Reclamation of mine waste rock dumps	2,391,326
3.	Decommissioning & closure of mine plant area.	1,983,339
Sub Total		5,433,265
15% contingency		814,990
Total mine site reclamation cost		**US$ 6,248,255**

6.7.2 Post Closure Site Inspection and Environmental Monitoring Cost

The Lumwana annual post closure site inspection and environmental monitoring cost estimate in years 1 and 2 is US$25,980. In years 3, 4, 5 and 10 the annual cost will reduce to US$22,365 because environmental monitoring will be annual instead of bi-annually. The total post closure site inspection and environmental monitoring cost is US$141,420. The cost breakdown by activity is shown in Table 6-9.

Table 6-9: Annual Post Closure Site Inspection and Environmental Monitoring Costs

Item No.	Post Closure Environmental Activity	Qty	Unit	Rate US$	Cost US$
1.	**Annual Mine Site Inspection**				
	• Mine site inspection to be conducted by independent consultant	15	days	$600	$9,000
	• Consultant's accommodation and transport	15	days	$250	$3,750
2.	**Bi-annual Environmental Monitoring**				
	• Technician to collect surface water samples	6	days	$350	$2,100
	• Technician to collect groundwater samples	1	days	$350	$350
	• Water sampling consumables	-	l.s.	$100	$100
	• Technician to take radon gas measurements	2	days	$350	$700
	• Radon gas meter consumables	-	l.s.	$100	$100
	• Surface & groundwater analytical cost	32	e.a.	$65	$2,080
	• Technician's accommodation and transport	9	days	$200	$1,800
3.	**Post Closure Environmental Reporting**				
	• Preparation of annual post closure environmental monitoring report by independent consultant.	10	days	$600	$6000
Total Annual Environmental Monitoring Cost					**US$25,980**

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Appendix A

Draft Terms of Reference and ECZ Letter of Acceptance

20 November 2002

The Director - Environmental Council of Zambia
Plot 6975 Suez Road
Ridgeway
P.O. Box 35131
LUSAKA

EQUINOX COPPER VENTURES LIMITED

Dear Mr. Phiri,

PROJECT: **LUMWANA COPPER PROJECT**
LOCATION: **NORTHWESTERN PROVINCE OF ZAMBIA**
DEVELOPER: **EQUINOX COPPER VENTURES LIMITED (EQCV) REGISTRATION NO.43254**

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)
DRAFT TERMS OF REFERENCE

In accordance with the requirements of the Environmental Protection and Pollution Control (Environmental Impact Assessment) Regulations, 1997, Part III Regulation 8 (3), Equinox Copper Ventures Limited hereby submits its draft Terms of Reference (TOR) for the Lumwana Copper Project in the Northwestern Province of Zambia.

EQCV initiated a Project Public Consultation Process on the 13th November 2002 by means of a Public Consultation Meeting, which was held at the Lumwana Site. This Meeting was advertised in the National Press and invitations were sent to His Royal Highness Chief Mukumbi, relevant government departments, local authorities and non-governmental organisations. Minutes of the Public Consultation Meeting are attached to the draft TOR.

The draft TOR have been developed from the following:-

- EIA Regulations, Part III, Regulation 8 & 11;
- Third Schedule of the Environmental Impact Assessment Regulations;
- The Lumwana Copper Project - Mine Plan
- The Developer's knowledge of the Lumwana site; and
- Results of the Lumwana Public Consultation Meeting.

I trust we have understood the regulations regarding preparation of EIA draft TOR correctly and look forward to receiving your comments in due course.

Yours sincerely,

Robert Rigo
Managing Director

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EQUINOX COPPER VENTURES LIMITED

Lumwana Copper Project

Environmental Impact Assessment

Draft Terms of Reference

1. Introduction

In accordance with the requirements of the Environmental Protection and Pollution Control (Environmental Impact Assessment) Regulations, 1997, Part III Regulation 8 (3) Equinox Copper Ventures Limited (EQCV) is required to submit Draft Terms of Reference (TOR) for its Lumwana Copper Project to the Environmental Council of Zambia (ECZ) for approval.

2. Scope of Work

The main objective of the TOR is to ensure that the Lumwana Environmental Impact Assessment (EIA) addresses all Project environmental and social impacts.

Environmental Consultants

Golder Associates of Perth Australia and African Mining Consultants (AMC) of Kitwe Zambia have been appointed by EQCV as environmental consultants for the Project Bankable Feasibility Study. AMC will undertake the EIA with overview by Golder Associates.

EQCV will direct AMC/Golder to provide information on all matters specified in EIA Regulations, Part III, Regulation 11 and other matters as are considered necessary by the Council.

Public Consultation Meeting

A Project Public Consultation Meeting took place at Lumwana Camp on the 13th November 2002 to ensure public views were taken into account in preparation of the TOR. The meeting was advertised in the National Press and invitations were sent to His Royal Highness Chief Mukumbi, relevant government departments, local authorities and non-governmental organisations. Minutes of the Public Consultation Meeting and EQCV's Environmental Policy for Mineral Exploration in Zambia are attached to the draft TOR.

The results of the Public Consultation Meeting have been taken into account in preparing the TOR.

EIA Document Structure

The proposed structure of the Lumwana EIA document conforms to the requirements of both the Zambian Environmental Regulations and international practices.

Proposed Lumwana EIA Structure

1. Executive Summary
2. Introduction
3. Legislation
4. Public Consultation
5. Project Description
6. Baseline Environmental & Social Study
7. Project Environmental and Social Impacts
8. Mitigating Measures
9. Environmental & Social Management Plan
10. Environmental Protection Costs

Baseline Environmental and Social Study

A 12 month detailed and comprehensive baseline environmental study of the project area will be undertaken to cover:-

- Climate;
- Air quality;
- Topography;
- Geology & Hydrogeology;
- Hydrology;
- Aquatic flora and fauna;
- Terrestrial flora and fauna;
- Land use and land classification evaluation;
- Background radiation survey;
- Noise;
- Archaeological & Cultural sites;
- Infrastructure and communications; and
- Social/cultural/economics

Environmental Impacts

The Lumwana Copper Project may have significant environmental and social/ cultural/economic impacts. The principal impacts to be addressed in the EIA are:-

- Hydrogeology.
  - seepage from waste rock dumps and tailings dams impairing groundwater quality
  - lowering of groundwater levels

- Hydrology.
  - river and stream diversion scheme around open pits
  - effects on surface water flow regime and quantity
  - surface runoff rates to surface waters
  - siltation of rivers and streams
  - effects on surface water quality of mine dumps and plant area runoff, tailings dam drainage and discharge of mine water

- Landscape.
  - visual impact of open pits, waste rock dumps, tailings dams, river diversion dams, diversion canal and plant area
  - use of water dams as amenities

- Terrestrial and aquatic flora and fauna.
  - loss of natural habitat
  - loss of timber resources
  - restricted movement of fauna
  - effects on flora and fauna bio-diversity
  - creation of new aquatic environments
  - natural regeneration of woodland
  - fish breeding and fish stocks

- Land use.
  - effects on land use and land potential in immediate project area and surrounds

- Infrastructure & Communications.
  - effect of increased road traffic
  - electrification of the Lumwana area
  - up-grading of the Chingola/Solwezi/Lumwana road

- Air Quality.
  - effects of dust generation from mining & blasting, ore and waste tramming, primary crushing, waste dumps and tailings blow on ambient air quality
  - SO_2 emissions from roaster plant

Social/Cultural/Economic Impacts

- Effect on employment opportunities in the project area.
- Construction of a mine village and associated infrastructure.
- Influx of new people attracted by enhanced employment opportunities.
- Friction between local people and immigrants and refugees vying for jobs.
- Resettlement of people living in the immediate project area.
- Effects of injection of money into local economy through salaries.
- Improved business opportunities especially for service industries to the mine.
- Opening up of mine roads providing easier access to forest reserve areas.
- Improved social/community services such as rural clinics, schools and recreation facilities

3. Schedule

The Project Bankable Feasibility Study (BFS) commenced in October 2001 and is planned to finish in mid-2003. The EIA is a key element of the BFS, which will be used to solicit funds for project development.

In order to complete the EIA by mid-2003 it was necessary to begin the 12 month baseline environmental study in November 2001. The baseline will be complete in December 2002. It was not possible to begin the permitting phase of the EIA before 13 November 2002 (date of Public Consultation Meeting) because mine planning/design was not at a sufficiently advanced stage.

AMC/Golder plan to complete the EIA in mid-2003.

21st January 2003 ECZ/EMP/92/5

The Managing Director
Equinox Copper Ventures Limited
P.O Box 110199
SOLWEZI

Dear Sir

RE: TERMS OF REFERENCE FOR LUMWANA COPPER PROJECT

The Environmental Council of Zambia (ECZ) wishes to acknowledge receipt of the above-mentioned TORs. I wish to inform you that the review process of the same TORs has been completed and TORs have been **approved.** However, take note of the following observations:

1. **TORs on page 2**:
   - The list of Proposed Lumwana EIA Structure should include Closure and Post Closure Plans as well as a Rehabilitation Plan
   - The comprehensive base line environmental study of the project area should include background levels of copper, cobalt, uranium and gold.
   - Hydrological aspects should also cover possible seepage from uranium tailings impoundments and the effects of the tailings on the aqua-ecosystem especially threatened species.

2. **Minutes of the consultative meeting**

   - The minutes on page 4 reviewed the issue of pumping water from the open pits and discharging into existing streams or dams. This water should undergo some suspended sediment removal process before discharge to the environment so as not to negatively impact the water for other downstream users.
   - On page 5, considering the sensitivity of uranium, the EIS should reflect adequate consultations with the Radiation Protection Board of Zambia whose presence is not indicated in the minutes.

We look forward to your continued cooperation.

Yours faithfully,

Mr. Felix Chabala
Senior Environmental Impact Assessment Officer (Acting)
For/Director
ENVIRONMENTAL COUNCIL OF ZAMBIA

Appendix B

EIA Public Consultation Meeting Minutes – 13 November 2002

Lumwana Environmental Impact Assessment (EIA)
Public Consultation Meeting

Project Name:	**Lumwana Copper Project**
Developer:	**Equinox Copper Ventures Limited (EQCV)**
	Incorporated in the Republic of Zambia - Reg. No.43254
Location:	**Lumwana Exploration Camp**
Date:	**13th November 2002**

Minutes of the Lumwana Copper Project EIA Public Consultation Meeting held at Lumwana Exploration Camp on 13th November 2002 at 09:30 hrs. The purpose of the Meeting is to ensure that public views are taken into account during preparation of the Project EIA Terms of Reference, in accordance with Part III Environmental Impact Statement Regulation 8 (2) of the Zambian Environmental Impact Assessment Regulations, 1997.

Prior to the start of the meeting tea and coffee was served in the Camp Mess from 08:00 hrs to 09:15 hrs. EQCV documentation and information packs describing the Lumwana Project were distributed as guests entered the meeting hall.

Opening Remarks

Chairman Mr. Elias Chipimo Jnr. opened the meeting at 09:15 hrs. Mr. Chipimo welcomed Honourable Chief Mukumbi, distinguished guests, ladies and gentlemen to Lumwana. He then introduced the following key EQCV personnel:-

Mr. Robert Rigo - Managing Director and Bankable Feasibility Study Manager;
Mr. Elias Chipimo Jnr. - EQCV Non-executive Director
Mr. Mike Richards - Exploration Manager Africa;
Mr. Steve Boda - Lumwana Site Manger; and
Mr. Mulenga Kafwilo - Administration, Community and Environment Officer.

And African Mining Consultants representatives:-

Mr. Andrew Spivey - Mining & Environmental Consultant; and
Dr. Mitulo Silengo - Socio-economic Consultant.

The Chairman requested all present to sign the attendance register giving their name, company/organisation and address. A copy of the attendance register is attached to these minutes. The Chairman then described the proposed itinerary for the day:-

O8:00 - 09:15 hrs:	Assemble at Lumwana Camp Mess, tea & coffee provided
09:15 - 11:00 hrs:	Presentation by Mr. R Rigo - EQCV Managing Director
11:00 - 12:00 hrs:	Questions & Answers Session
12:00 - 13:00 hrs:	Lunch provided by EQCV
13:00 - 15:00 hrs:	Site visit to Malundwe and Chimiwungo work areas
15:00 - 16:00 hrs:	Afternoon tea & coffee, Summary and Question & Answers
16:00 hrs:	Close

The Chairman stressed that it was important to keep to the schedule in order to close at 16:00 hrs and allow participants adequate time to return to Solwezi before dusk.

The Chairman then called upon Mr. Robert Rigo to make the presentation, which began at 09:25 hrs.

Power Point Presentation of the Lumwana Copper Project

Introduction

Mr. Rigo began by welcoming all present. He went on to describe EQCV's Australian parent company Equinox Resources Limited (EQR) as a respected, integrated Australian explorer - developer. EQR has been quoted on the Australian stock exchange since 1994. Its major shareholders are Lion Selection (15.3%), BHP Billiton (9.9%), M & G (5.9%) and the Board of Directors (10.7%). The Company's financiers are the European Investment Bank, Rand Merchant Bank, South African Export Development Fund and Société Générale. The company's Board of Directors are:-

Geoff Reynolds	-	Chairman; Geologist
Craig Williams	-	Managing Director; Geologist
Bruce Nisbet	-	Technical Director; Geologist
Geoff Simpson	-	Non-Executive Director; Lawyer
Mike Klessens	-	Company Secretary; Accountant

Mr. Rigo explained that EQR had no producing mines. However, the company is carrying out copper and gold exploration in Australia, Sweden and Zambia in addition to the Lumwana Bankable Feasibility Study in Northwest Zambia. EQR Joint Venture Partners are BHP Billiton in Australia and Sweden, and Phelps Dodge (Lumwana) and Anglo American (Zambezi) in Zambia.

Mr. Rigo pointed out that EQCV was in Zambia because the country has an attractive environment for mine development including a free market economy, attractive foreign investment policies post privatisation of Zambia Consolidated Copper Mines (ZCCM) and an existing mining culture. The Zambia Copperbelt is one of the World's Great Metal Provinces. Historically the Province has produced over 30 million tonnes of copper metal but only limited exploration has taken place in the last 25 years.

EQCV entered into a Joint Venture Partnership with Phelps Dodge Mining at Lumwana in 1999. EQCV currently owns 50% of the Project but this can be increased to 75%.

EQCV's Board of Directors are:-

Craig Williams	-	Chairman; Geologist
Robert Rigo	-	M.D. and BFS Manager; Engineer
Elias Chipimo Jnr.	-	Non-executive Director; Lawyer
Robert Sievers	-	Non-executive Director; Accountant

Mr. Rigo highlighted that 95% of the 155 strong Lumwana work force are Zambian citizens.

The Lumwana Project Bankable Feasibility Study (BFS) has a budget of US$13 million. The BFS is scheduled to be complete in mid-2003. The Project key contractors & consultants are:-

Kvaerner	-	Principal Consultant
Golder Associates	-	Geo-sciences
African Mining Consultants	-	Environment/rock mechanics/geotech
AMMTEC	-	Metallurgical Laboratories
Stanley Drilling	-	Drilling

Mr. Rigo stated that the Project BFS must satisfy the following criteria:-

Technical Acceptability;
Financial Acceptability;
Environmental Acceptability; and
Government of Zambia and Community Acceptability.

At the same time the Project must satisfy both Zambian and International Standards.

Lumwana Resources

The Lumwana Resources key facts are presently stated as:-

Geological Resource :	1,064 Mt @ 0.7% Copper
By-products:	Cobalt/Gold/Uranium
Mining Resource:	330 Mt @ 0.74% Copper
Open Pit Stripping Ratio:	3.2:1
Production Rate:	14.5 Mtpa (copper ore)
Mine Life:	24 Years

These figures are subject to change / update, as the project's BFS is developed.

The Lumwana ore deposits occur in two blocks namely the Malundwe and Chimiwungo Deposits. The deposits are approximately 7 Kilometers apart. The Malundwe deposit is 4.8 Km long by 0.5 Km wide with an average thickness of 33 metres. The Chimiwungo deposit is 4.2 Km long by 3.6 Km wide with an average thickness of 82 metres. The Chimiwungo deposit is faulted and will be mined as two separate north and south pits.

Mining Summary

It is planned that all mining will be open cut. The Malundwe pit will be approximately 140 metres deep and the Chimiwungo South Pit will be up to 240 metres deep. Up to 75 Mt of material will be moved. Contractors will be used for mining, drilling and blasting. The open pits will be of conventional design with 12 m high benches. Pit de-watering will be both from within the pit and pump wells located outside the pit. Laboratory analysis indicates the waste rock to be non-acid producing.

Hydro-geological Summary

Drilling is currently taking place to evaluate possible water inflows to the pits. Monthly monitoring of groundwater indicates that it is consistently of good quality. The pits will need to be de-watered for some time before mining commences and throughout mining operations. Water pumped from the open pits will be discharged into existing streams or dams. Water quality will be regularly monitored to ensure compliance with Zambian and International Standards.

Environmental Baseline

A 12-month environmental baseline study commenced in November 2001. The recently completed baseline study covered the following areas:-

Climate
Air quality
Topography
Geology

Hydrogeology
Hydrology
Terrestrial & Aquatic Flora & Fauna
Land Use and Land Classification Evaluation
Background Radiation Survey
Noise
Infrastructure & communications
Socio-economics

EQCV is continuing to monitor water quality.

Metallurgical Test Work Communition

The copper ore consists of coarse sulphides; chalcopyrite and bornite. The ore breaks easily along foliations with relatively low work indices. The ore will be processed through a conventional circuit i.e. primary crush, semi autogenous grind (SAG) and flotation. Test work indicates that the ore floats easily and quickly with low reagent consumption. The grind is relatively coarse at 80% passing 300 microns compared to typical Zambia Copperbelt ore grinds of 80% passing 75 microns. This will realize significant energy savings. Copper recovery is 95-97% with a concentrate grade of 28-45% copper.

Metallurgical Process Description - Copper Ore 14.5 Mtpa

Copper ore will be primary crushed to produce a feed stockpile for the SAG mill. The SAG product is then screened. The undersize material proceeds directly to the concentrate flotation circuit while the oversize material first goes through a further grinding stage in a ball mill. Copper flotation concentrate is pumped to the Roast/Leach/Electro-win (RLE) Plant where copper cathode, cobalt and gold are produced. The viability of recovering gold is still being investigated. Sulphur dioxide captured from the roaster is processed through an acid plant to produce sulphuric acid that will be marketed regionally. Waste from the flotation circuit will be deposited in the tailings dam.

Metallurgical Process Description - Uranium/Copper Ore 0.8 Mtpa

Uranium/Copper ore will be processed in a separate facility. The ore will be primary crushed to produce a feed stockpile for the SAG mill. The milled material is leached with sulphuric acid and the product pumped to the Solvent Extraction Plant (SX). Uranium is precipitated from the SX plant slurry to produce Yellow Cake. Waste material is pumped to a dedicated lined waste storage facility. The solution from the SX Plant contains copper and is pumped to the copper electro-winning plant to recover the copper.

Tailings

The mine will produce copper tailings and uranium tailings.

Copper tailings will be deposited in a constructed dam (years 1-6) and then in the Malundwe open pit (years 6-24).

Uranium tailings will be deposited in an engineered, lined dam.

Laboratory test work indicates that the tailings are non-acid producing.

ine Development

With the aid of 3-dimensional plans Mr. Rigo described the development of the mine from Year 0 - Start of Mining to Year 20 - Mine Closure.

Situation Year 0
A series of dams have been constructed prior to the start of copper production.

A copper tailings dam has been constructed across the East Lumwana River approximately 2 km upstream of the Malundwe open pit.

A water dam has been constructed across the East Lumwana River several kilometers upstream of the copper tailings dam. And two additional internal tailings dam starter walls have been constructed between the main tailings dam wall and the water dam.

A diversion canal has been constructed to divert the East Lumwana River around the Malundwe Open Pit. The Chimiwungo Stream and Malundwe Stream have also been dammed as part of the river diversion scheme. It is expected that the water dam will fill during one wet season and spill into the diversion canal.

The plant area, uranium tailings storage facility and mine village located upstream of the water have also been constructed.

Situation Year 2
Malundwe open pit is in production. Waste rock has been placed across the East Lumwana River Valley to support the tailings dam wall.

Copper tailings are being deposited from the main tailings dam, internal walls and down stream of the water dam.

Uranium tailings are being deposited in the engineered, lined storage facility.

All water dams are full and the diversion canal is operating.

Situation Year 5
Mining of the Malundwe open pit has reached an advanced stage. Dumping of waste rock across the East Lumwana River Valley below the main tailings dam wall has stopped and progressive rehabilitation of the dump has started. Waste rock from Malundwe pit is now dumped on the north side of the valley.

Copper tailings storage capacity in the East Lumwana River Valley is almost exhausted.

Deposition of uranium tailings ceased in Year 3-5. The uranium process plant is being decommissioned.

Overburden stripping in Chimiwungo South open pit has started. Waste is being stored on dumps to the south and west of the pit.

Situation Year 10
Tailings deposition in the East Lumwana River Valley has ceased and progressive rehabilitation of the tailings surface has started.

Mining of the Malundwe open pit is complete and in-pit tailings deposition has commenced.

The uranium tailings storage facility has been rehabilitated and decommissioned.

The Malundwe waste rock dump has reached its full extent.

Mining of Chimiwungo South Pit is almost complete. A new waste rock dump has been opened to the east of the pit.

Situation Year 15
Deposition of tailings in Malundwe open pit is continuing.

Production has started from the Chimiwungo East Pit. The Chimiwungo south and west waste dumps are being re-vegetated. All waste is now dumped to the east of the pits.

Situation Year 20
Deposition of tailings in Malundwe open pit is continuing.

Production has started from Chimiwungo North and Main Pit.
The Malundwe waste rock dump has been re-vegetated. Rehabilitation of the waste rock dump situated to the east of the Chimiwungo pits has started.

Situation Year 24 (Mine Closure)
Progressive rehabilitation of tailings dams, waste rock dumps and open pit mines is complete.

The plant area has been decommissioned and a post closure site monitoring programme implemented.

Mine Infrastructure

In terms of project infrastructure EQCV will promote home ownership by its employees, contracting of services, private investors and entrepreneurs, self managed sports clubs, community groups and provide some social services such as a school and clinic to be handed over to the government to run.

The Company will construct all mine roads. However, the Lumwana-Copperbelt road will need upgrading. When the mine is operating it is anticipated that there will be 2-3 truck movements per hour. Assistance will be sought from the Zambian Government and international donor agencies to fund this road project.

The Lumwana Project will be a large consumer of power. Subsequently the power line from the Copperbelt will need upgrading from 66 kV to 330 kV. Although this is an expensive undertaking, the cost has been factored into the Project. However, assistance will also be sought from the Zambian Government and international donor agencies to fund this aspect of the Project.

EQCV has not factored in the cost of a railway line because it is too expensive to construct. Nevertheless a railway line would be beneficial for Lumwana, the Northwestern Province and Zambia. Construction would have to be funded by an international donor agency or a private company.

EQCV will construct water dams and reticulate water. All dams will be designed for storm events and overflow in to existing streams. The river diversion scheme will have minimal impact on the East Lumwana River because there are many tributaries downstream of the Lumwana project and stream flow will be augmented from open pit de-watering.

Lumwana Annual Production

Lumwana planned average annual production is as follows:-

Copper	106,000 tpa
Cobalt	3,000 tpa
Gold (Malundwe)	18,000 ozspa
Acid H_2SO_4	200,000 tpa
Uranium (3-5 years)	1,200 tpa

Preliminary Project Capital Cost Estimate

On site Roast/Leach/Electro-win RLE (base case scenario)	US$450 millions
Copperbelt Smelting of concentrates	US$250 millions

It is feasible that the Lumwana Project will have two phases:-

Phase I	Copperbelt smelting of Lumwana concentrates
Phase II	RLE of Chimiwungo concentrate on-site or on Copperbelt

These capital costs include for an upgrade of the power line but do not include for mining equipment (mining contractor to be used), Lumwana-Copperbelt road upgrade or railway.

Project Development Schedule

Regarding the development schedule, if the results of the Bankable Feasibility Study are favorable financing will be obtained before the end of 2004. Thereafter detailed design, construction and commissioning will be done by 2006. In the most optimistic scenario production would commence in 2006.

Project development is dependent on the following factors:-

- **Copper price**
- Credit metal prices
- Capital cost of development
- Support from Joint Venture Partner
- Support from Zambian Government and International Donor Agencies
- Project financials
- Support from financing houses
- Support from Shareholders

Preliminary indications are that the price of copper must be at US$0.80/lb or more for the project to be robust. The predicted copper price by several reputable metals analysts is US$0.95/lb in Year 2006. A project such as Lumwana with a mine life of 24 years will benefit from the long-term metal price cycles.

Operations

In its operations the Lumwana Project will have approximately 1000 employees for the base case scenario and 750 employees for the concentrate production only scenario. Employment criteria will be applied during recruitment. Preference will be given to local people depending on available skills. However, specialists will need to be recruited, some of them from beyond Solwezi and Zambia. Training and development of skills for employees will be provided where necessar. Health and safety of employees will be an important aspect of the company.

Mine Closure

The planned life of the mine is 24 years. However, the mine life is likely to be extended by further exploration.

Progressive rehabilitation of the mines tailings dams and dumps will take place throughout the life of the mine.

Civil engineering structures such as the dams and the river diversion canal will be retained for the benefit of the community. The dams may be used for crop irrigation, aquaculture, leisure and wildlife tourism. The open pits will also retained as water reservoirs.

EQCV is committed to working closely with the community.

Closing Remarks and Conclusions

Mr. Rigo commented that in the early 1970's copper production peaked on the Zambia Copperbelt at 700 ktpa. Today Copperbelt production is of the order of 250-300 ktpa.

If both the Kansanshi Copper Project and the Lumwana Copper Project go ahead the combined copper production will be between 200-250 ktpa constituting a 'new' Northwest Copperbelt.

Mr. Rigo predicted that the focus of the Zambia copper industry would shift to the Northwestern Province over the next 10 years as the ageing and high cost Copperbelt Mines become less viable to operate. There is an opportunity to develop low cost open cut mines using state of the art technology.

Conclusions on Lumwana Project

- Major Cu-Co-U-Au resource on a world scale;
- Potential to produce > 100,000 tpa copper
- US$13 million for financing of Lumwana Bankable Feasibility Study
- Strong financier group including EIB-RMB-SAEDF-SOC GEN
- A major BFS is underway
  - Internationally recognized team of Kvaerner and Golders Associates
  - BFS to be completed in mid-2003
- Aim to raise financing by 2003/04; subject to markets
  - Two years for development
  - Production from year 2006, if all goes well.

Mr. Rigo's presentation finished at 10:40hrs. After the presentation Mr. Chipimo Jnr. invited the participants to a Question and Answer Session.

Question and Answer Session

Shadreck Nsongela (Environmental Council of Zambia)

Observations: (i) He wondered whether all the people present were able to follow the presentation in English; and (ii) He reminded those present that the purpose of the meeting was to assist the developer to broaden the scope of issues to be addressed in the Environmental Impact Assessment, either bio-physical or socio-economic.

Answer: The Chairman observed that His Royal Highness Chief Mukumbi had absorbed the presentation and will convey the issues to his subjects. The Chairman asked if anyone present had not understood the English presentation. There was no response. The Chairman stated that a synopsis of the presentation would be made available in the local language if requested. No request was made.

D. Hambote (Archaeologist - National Heritage Conservation Commission)

Question: There has been no mention of any possible archaeological sites in the mine are?

Answer: A. Spivey (AMC)
The issue of possible archaeological sites in the mine area will be addressed in the EIA. Initial indications are that there are no archaeological sites close to the mine. Archaeological sites are known to occur several kilometers from the mine site.

Comment: D. Hambote
As land is cleared the Company should liaise with local people to identify any archeological sites.

Comment: M. Munyima (Director - National Heritage Conservation Commission)

There will be need for a cultural resources specialist on the team to identify archaeological sites at the mine. Mr. Munyima thanked Mr. Rigo for a comprehensive and clear presentation.

- -

B. Hamafuwa (Spectra Oil)

Question: Could you make a statement on:-

(i) Existing villages and impact of displacement of people by project development; and
(ii) Discussions with/briefing of government, relevant authorities and donor agencies on project requirements i.e. power supply and roads?

Answer: His Royal Highness - Chief Mukumbi
(i) At present there are no existing villages on the site apart from illegal fields situated in the forest reserve area. There is enough land in Mukumbi area for farming and those individuals have been told to move. The mine will attract people. When the mine compound is developed the Forestry Department will be approached to degazette the forest for settlement and farming.

Observation: M. Kafwilo - Administration & Environmental Officer EQCV

A census was taken of all villages along the road and records are available. It is possible that some new settlers may not have been captured.

Answer: R. Rigo - Managing Director EQCV

(ii) Regular consultation has been made with the Mines Safety Department and Environmental Council of Zambia. The Company has kept government officials updated/informed concerning the Project status. Honourable Mr. Davison Mulela MP & Minister for Mines Development and Honourable Mr. Bert Mushala, MP & Deputy Minister (North West Province) visited the site in June 2002. His Excellency Mr. Levy Mwanawasa was briefed in June 2002 when senior company officials had occasion to meet him in Kitwe and discuss road, rail and power issues.

The European Union, USAID and the Energy Regulation Board of Zambia have been contacted regarding infrastructure development. Support is needed from government for infrastructure development in Lumwana. Donors need to know that the Project is viable economically and environmentally before committing.

His Royal Highness - Chief Mukumbi

Point of correction: There is a point of correction concerning the names Chimiwungo and Nkulumazhiba. Whereas the mine site is referred to as Chimiwungo, the proper name is Nkulumazhiba. It is the Nkulumazhiba Stream and not the Chimiwungo Stream.

Answer: R. Rigo - Managing Director EQCV

The comment is noted. The legal issue will be addressed.

Answer: E. Chipimo Jnr. Non-Executive Director EQCV

This may be an opportune time to rectify the mistake of the past.

I. Munkata (Chief Lands Officer - Ministry of Lands, Lusaka)

Question: Are there any people holding land title deeds that would be affected by the development of the mine?

Answer: M. Richards - Exploration Manager Africa EQCV

There is no freehold land in the area to be affected by mining operations. The land is either (i) Forestry Reserve or (ii) Chief Mukumbi's Chiefdom.

Answer: His Royal Highness - Chief Mukumbi

There are no title deeds to any of the affected land.

R. Ngoma (Spectra Oil)

Question: (i) Are any royalties to be paid to the Chief?
(ii) Is EQCV a serious investor, particularly concerning ZESCO?

Answer: E. Chipimo Jnr. Non-Executive Director EQCV

(i) Under current law there is no interaction between the Chief and the Developer - EQCV. However, a relationship has developed which has resulted in community assistance i.e. the clinic that is being built in the area. The Mines and Minerals Act and the Income Tax Act provides for payment of royalties to the government.

Answer: R. Rigo - Managing Director EQCV

(i) There is a 0.6% metal tax (royalty) paid to the government.

(ii) EQCV has provided ZESCO with detailed project power requirements. Project viability will be known after the BFS is complete. I am confident however that the Project will proceed after the BFS and when financing has been secured from investment partners.

J.M. Chilufya (Assistant Conservation Geo-morphologist, NHCC)

Question: What action will the Company take on accidental spillages?

Answer: R. Rigo - Managing Director EQCV

Laboratory test work indicates that the mine waste is non-acid producing. Uranium tailings will be stored separately in a lined dam and will not present a danger. Uranium levels in the dams will be well within international standards.

The company will construct conventional engineered waste storage facilities and implement good management practices to ensure there are no spills. Groundwater and surface water quality will be regularly monitored. Laboratory test work indicates that the tailings are 'environmentally friendly'.

Answer: M. Richards - Exploration Manager Africa EQCV

The uranium is currently exposed to the atmosphere via groundwater drainage. Mine discharge levels will be less than the background level.

A. Muvundika (Environmental Inspector - Mines Safety Department)

Question: Will the Company use different/better dam designs than the Copperbelt mines to prevent dam erosion?

Answer: R. Rigo - Managing Director EQCV

All dams will be properly engineered valley dams constructed using barren rock and clay liners to ensure structural stability, rather than paddock dams with walls constructed using tailings material.

M. Munyima (Director, NHCC)

Question: (i) You indicated 11 geologists, 24 camp staff, and 120 field personnel. What about short, medium and long-term employment?

(ii) Who owns the remaining 61% of shares in Equinox Resources?

Answer: R. Rigo - Managing Director EQCV

(i) The numbers quoted in this presentation reflect employees on site for drilling and site operations during 2002.

The number of mine employees will be defined in detail in the next 6 months after completion of design. AMC will be addressing socio-economic issues in the EIA including the number of employees.

(ii) Remaining Equinox Resources shares belongs to 2000 individual shareholders.

Answer: M. Richards - Exploration Manager Africa EQCV

(i) During the project construction phase the number of employees is expected to peak at between 1500 and 2000 for the base case scenario.

M. Tamina (B & M Computer Associates)

Question: (i) If the necessary funds are not solicited for the project and the Company leaves, will there be any environmental impact?

(ii) Will the company try to use local contractors? General experience is that foreign contractors come and go.

Answer: M. Richards - Exploration Manager Africa EQCV

(i) Exploration at Lumwana has been ongoing since the early 1960's by RST, AGIP, Phelps Dodge and now EQCV. The present BFS study will add value to the Project. If at the end of the study the Project is not viable Lumwana will not be in a worse environmental situation.

Answer: R. Rigo - Managing Director EQCV

(ii) The Company will use local contractors who can provide quality work. The Company will also encourage a local contractor base.

J.M. Chilufya (Assistant Conservation Geo-morphologist, NHCC)

Question: Will wildlife be affected by the Project?

Answer: (A. Spivey (AMC)

Studies so far indicate that there is little terrestrial wild life in the Project area except for small mammals, reptiles and birds. The larger animals have been poached out. A wild life survey is included in the baseline study.

D. Hambote (Archaeologist - National Heritage Conservation Commission)

Question: Will the construction of dams on the river have an impact on people downstream?

Answer: R. Rigo - Managing Director EQCV

The dams will have minimal impact on the East Lumwana River downstream of the Project. This is a high rainfall area and there are a lot of feeder streams downstream of the Project. Mine water pumped from the pits will be put into the river downstream. The hydrologist will model the impact of the dams on river flow. No impact is envisaged at the moment for downstream users.

M. Munyima (Director, NHCC)

Comment: The presentation indicates that a democratic system was put in place in 1991 and re-elected in 1996. For the record democratisation was put in place in 1991 and the government was re-elected in 1996.

His Royal Highness - Chief Mukumbi

Observation & Comment: Chief Mukumbi noted that Mr. Paul Mkoma - Deputy Permanent Secretary for Northwestern Province had arrived late. The Chief asked the Chairman if it would be possible for Mr. Rigo to go through the presentation again quickly before Lunch for the benefit of Mr. Mkoma.

Answer: E. Chipimo Jnr. Non-Executive Director EQCV
Mr. Rigo will gladly give a presentation to Mr.Mkoma between 11:30 to 12:00 hrs.

The Chairman closed the Question & Answer Session at 11:30 hrs. He invited everyone to Lunch in the Camp Mess from 12:00 to 13:00hrs. He requested that those 55 participants who had indicated their wish to go on the site visit to assemble in the car park at 13:00 hrs.

Site Visit to Malundwe and Chimiwungo work areas 13:00 - 15:00 hrs

The first stop on the site visit was in the northern copper clearing at the site of the proposed Malundwe open pit. Here, Mr. M. Richards of EQCV gave a brief explanation for the copper clearing and with the aid of a site plan described the Malundwe mine site, and local landmarks. The second stop was on the southern edge of the Chimiwungo dambo close to Chimiwungo main pit. Again with the aid of a plan Mr. M. Richards described the location of the Chimiwungo main pit and its position relative to the Malundwe pit, the mine plant area and mine village. He explained that the Chimiwungo Stream would also have to be diverted via a diversion canal although the structure would be much smaller than that on the East Lumwana River.

The site visit finished at 15:30 hrs

Afternoon tea and cakes were served between 15:30 and 15:45 hrs.

Closing Question and Answer Session

At 15:45 hrs participants reconvened in the meeting hall for the closing Question and Answer Session.

R. Pearce (Turnpan Zambia Limited, Komatsu Mining and Construction)

Question: Could you please tell me the specific gravity of the ore and waste, the gradient of the pit ramps and the scale of the plans provided in the Lumwana Project information pack.

Answer: R. Rigo - Managing Director EQCV

Specific Gravity of Ore:	SG = 2.78 t/m^3
Specific Gravity of Waste:	SG = 2.70 t/m^3
Design gradient of pit ramps:	10 percent

Mr. Rigo apologised for the absence of a scale on the site plans.

M. Shimabale (CELTEL)

Question: Will the Lumwana PowerPoint Presentation be made available to the Public Consultation participants?
Answer: R. Rigo - Managing Director EQCV
The presentation will be made available to those who would like copies. Mr. Kwafwilo EQCV will take the names of those who want copies.

His Royal Highness - Chief Mukumbi

Statement: What does the local Chieftainship receive in concessions? There will be a lot of benefits in the area. There will also be numerous problems with the introduction of the mine. Local culture will change and crime levels will grow. The Chieftainship should get a certain percentage of the mine earnings. Good concession would be an understanding between the mine and the Chieftainship to be endorsed by the government.

I would like to thank the Managing Director for the start in terms of relationship between the Company and Chieftainship and for involving the local leadership so it can explain the Project to its people. We have so far enjoyed a good relationship with the Company, which has assisted the Chieftainship.

Reply: R. Rigo - Managing Director EQCV
Mr.Rigo thanked His Royal Highness - Chief Mukumbi, Mr. Chipimpo Jnr. Mr. Richards and everyone present for their participation in the Public Consultation process. He stated that the participant’s comments would be used positively in preparing the Terms of Reference for the Project Environmental Impact Assessment (EIA).

The Meeting Closed at 16:00 hrs

List of Participants

No.	Name	Company / Organisation	Address
1.	Chief Mukumbi	Mukumbi Royal Establishment	P.O. Box 110176, Solwezi
2.	Mr. K. Kapumba	Mukumbi Royal Establishment	P.O. Box 110212, Solwezi
3.	Mr. P Mkoma	Deputy Permanent Secretary, Office of the Cabinet Minister - NW Province	P.O. Box 110100, Solwezi
4.	Mr. S.W Phiri	C.T Hughes Limited, Ndola	P.O. Box 70753, Ndola
5.	Mr. C. Chikwanda	Changa Changa Motel, Solwezi	P.O. Box 110249, Solwezi
6.	Mr. A. Muvundika	Ministry of Mines & Minerals Development - Inspector, Mines Safety Department	P.O. Box 21006, Kitwe
7.	Dr. M. Silengo	African Mining Consultants Limited, Kitwe	P.O. Box 20106, Kitwe
8.	Mr. J.M Chilufya	Geomorphologist - National Heritage Conservation Commission - NW Region	P.O. Box 110247, Solwezi
9.	Mr. D. Hambote	Archaeologist - National Heritage Conservation Commission - NW Region	P.O. Box 110247, Solwezi
10.	Mr. M. Munyima	Director - National Heritage Conservation Commission - NW Region	P.O. Box 110247, Solwezi
11.	Mr. A Phiri	Driver - Ministry of Lands,	P.O. Box 30069, Lusaka
12.	Mr. I. Mukata	Chief Lands Officer - Ministry of Lands	P.O. Box 30069, Lusaka
13.	Mr. B. Mulopa	Ward Councillor, Mumbezhi	P.O. Box 11070, Solwezi
14.	Mr. E. Mumba	Driver - National Heritage Conservation Commission - NW Region	P.O. Box 110247, Solwezi
15.	Mr. H.M Ngulubwe	Zambia State Insurance Company Limited (ZSIC), Ndola	P.O. Box 290036, Ndola
16.	Mr. S.A Syapaka	Zambia State Insurance Company Limited (ZSIC), Ndola	P.O. Box 290036, Ndola
17.	Mr. R. Kachungu	Zambia State Insurance Company Limited (ZSIC), Solwezi	P.O. Box 110133, Solwezi
18.	Mr. D. Lizebete	Professional Insurance Corporation Zambia, Ndola Office	P.O. Box 70238, Ndola
19.	Mr. B. Hamafuwa	Spectra Oil Corporation Limited, Kitwe	P.O. Box 21086, Kitwe
20.	Mr. L. Mpokosa	Stefanutti & Bressan (Zambia) Limited, Kitwe	P.O. Box 22561, Kitwe
21.	Mr. M. Tamina	B & M Computer Associates, Kitwe	P.O. Box 22561, Kitwe
22.	Mr. R. Ngoma	Spectra Oil Corporation Limited, Kitwe	P.O. Box 21086, Kitwe
23.	Mr. H. Mwenya	Chilanga Cement Plc, Ndola	P.O. Box 71572, Ndola
24.	Mr. I. Mpandawike	Blackwood Hodge (Zambia) Limited, Kitwe	P.O. Box 22700, Kitwe
25.	Mr. J.G Mwanza	Blackwood Hodge (Zambia) Limited, Kitwe	P.O. Box 22700, Kitwe
26.	Mr. B. Mukonga	Mukumbi Royal Establishment	P.O. Box 110212, Solwezi
27.	Mr. R. Ferenczy	Indotech (Zambia) Limited, Chingola	P.O. Box 10944, Chingola
28.	Mr. A. Simbeya	Indotech (Zambia) Limited, Chingola	P.O. Box 10944, Chingola
29.	Mr. R. Shiel	Zalawi Haulage Limited, Chingola	P.O. Box 11087, Chingola
30.	Mr. R. Pearce	Turnpan (Zambia) Limited, Komatsu Mining & Construction, Kitwe	P.O. Box 20457, Kitwe

List of Participants (cont.)

No.	Name	Company / Organisation	Address
31.	Mr. B. Lombe	Turnpan (Zambia) Limited, Komatsu Mining & Construction, Kitwe	P.O. Box 20457, Kitwe
32.	Mr. E. Chipimo	Corpus Globe - Advocates, Lusaka	P.O. Box 32115, Lusaka
33.	Mr. A. Spivey	African Mining Consultants Limited, Kitwe	P.O. Box 20106, Kitwe
34.	Mr. P. Mpongosa	Zamanglo Prospecting Services Limited, Kitwe	P.O. Box 20184, Kitwe
35.	Mr. T. Kakonde	CELTEL *Lets Talk*, Kitwe	P.O. Box 20760, Kitwe
36.	Mr. M. Shimabale	CELTEL *Lets Talk*, Kitwe	P.O. Box 20760, Kitwe
37.	Mr. J.C Kawesha	CELTEL *Lets Talk*, Kitwe	P.O. Box 20760, Kitwe
38.	Mr. S. Emsley	Barlows Equipment Company Limited, Lusaka	P.O. Box 328906, Lusaka
39.	Mr. G. Sinyani	Barlows Equipment Company Limited, Kitwe	P.O. Box 20810, Kitwe
40.	Mr. S. Nsongela	Environmental Council of Zambia (ECZ), Ndola	P.O. Box 71302, Ndola
41.	Mr. V. Mulenga	Environmental Council of Zambia (ECZ), Ndola	P.O. Box 71302, Ndola
42.	Mr. R.R Chisanga	Ministry of Home Affairs - Immigration Department, Solwezi	P.O. Box 110061, Solwezi
43.	Mr. P. Sikasamba	Ministry of Environment & Natural Resources - Forest Research Division, Kitwe	P.O. Box 22099, Kitwe
44.	Mr. G. Wright	Quatro Limited, Kitwe	P.O. Box 22463, Kitwe
45.	Mr. D. Klironomos?	Quatro Limited, Kitwe	P.O. Box 22463, Kitwe
46.	Mr. D. Nyambe	Office of the President, Solwezi	P.O. Box 110052, Solwezi
47.	Mr. L. Muwongo	Ministry of Home Affairs - Solwezi Police	P.O. Box 110002, Solwezi
48.	Mr. E.M Lwato	Office of the President, Solwezi	P.O. Box 110052, Solwezi
49.	Mr. P.M Mukumbi	Mukumbi Royal Establishment	P.O. Box 110176, Solwezi
50.	Mr. E. Kanche	Equinox Copper Ventures Limited, Lumwana	P.O. Box 110199, Solwezi
51.	Mr. S. Chisela	Equinox Copper Ventures Limited, Lumwana	P.O. Box 110199, Solwezi
52.	Mr. M. Kafwilo	Equinox Copper Ventures Limited, Lumwana	P.O. Box 110199, Solwezi
53.	Mr. L. Luchimbe	Equinox Copper Ventures Limited, Lumwana	P.O. Box 110199, Solwezi
54.	Mr. R. Rigo	Equinox Resources Limited, Perth, Australia	P.O. Box 497, West Perth
55.	Mr. G. Hewlett	Equinox Copper Ventures Limited, Lumwana	P.O. Box 110199, Solwezi
56.	Mr. M. Richards	Equinox Resources Limited, Perth, Australia	P.O. Box 497, West Perth
57.	Mr. W. Mulenga	Equinox Copper Ventures Limited, Lumwana	P.O. Box 110199, Solwezi
58.	Miss. A. Hanson	Equinox Copper Ventures Limited, Lumwana	P.O. Box 110199, Solwezi
59.	Mr. S. Boda	Equinox Copper Ventures Limited, Lumwana	P.O. Box 110199, Solwezi

Appendix C

Sustainability Policy

HEALTH, SAFETY, ENVIRONMENTAL AND SOCIAL POLICY

Equinox Copper Ventures Limited (ECV) is committed to the continuous improvement in its health, safety, environmental and social performance believing that such improvements are good business practice which contribute to shareholder and stakeholder confidence and value. As such ECV will minimise the impacts of its mining and treatment operations on the physical environment and on adjacent communities.

To achieve this, ECV will:

- Comply with all applicable national laws, regulations, licence and permit conditions as a minimum standard for its environmental practices and management procedures for its activities in Zambia;

- Ensure the necessary resources are provided to maintain a health, safety and environmental (HSE) management system to continually improve our operations.

- Integrate HSE considerations into all activities including exploration, mine planning, mining and processing operations.

- Prevent, eliminate and/or control identifiable hazards to minimise work related injuries and illness.

- Perform regular HSE audits and inspections to assess the performance of the project.

- Facilitate the education of our employees and contractors in relation to their roles and responsibilities in HSE management in respect of ECV's activities

- Establish permanent lines of communication with local communities to ensure concerns are addressed.

- Develop strategies and programs with key stakeholders to support and realise the positive benefits of the development.

- Actively engage key stakeholders in the planning and implementation processes to ensure adverse impacts on the environment are minimised.

- Co-operate with all relevant national regulatory agencies, local government and communities to enhance environmental protection and stakeholder confidence in ECV's activities.

Harry Michael
Managing Director
EQUINOX COPPER VENTURES LIMITED
28th July 2005

Appendix D

Characterisation of Environmental Impacts

ENVIRONMENTAL IMPACT CHARACTERISATION

The key environmental aspects/issues and associated impacts relate to each mine component and the pre-mining, operational and post closure phase where appropriate. They have been characterised using both qualitative assessment and quantitative evaluation where relevant data is available. The criterion used to characterise the environmental impacts is explained in Table D-1.

Table D-1: Criterion and Terms Used to Describe Potential Environmental Impacts

Item No.	Impact Criterion	Description	Criterion Classification	
			Term	**Description**
1.	Positive or Negative Impact	Will the impact have a positive or negative effect on the environment?	Positive	A positive impact.
			Negative	A negative impact.
2.	Likelihood of Impact Occurring	What is the likelihood/certainty associated with a potential impact?	Unlikely	Unlikely to occur.
			Possible	May possibly occur.
			Probable	Likely to occur.
			Certain	Certain to occur.
3.	Timing of Impact	At what point in time will the impact occur / be felt?	Pre-mining	Site construction phase.
			Start of mining	Will occur immediately mining operations begin.
			Near-future	Will occur within the lifetime of the mine.
			Mid-future	Will occur after the mine has closed.
			Distant-future	Will occur in the distant-future.
4.	Duration of Impact	What is the likely duration or time over which the impact will occur / be felt?	Indeterminate	Unable to be predicted with certainty.
			Short-term	Will cease once activity stops.
			Medium-term	Will continue for the lifetime of the mine.
			Long-term	Will continue beyond mine closure.
			Permanent	Will remain permanently.
5.	Extent of Impact	What is the geographical extent of the impact?	Project Area	Will affect the immediate mine area.
			Regional	Will affect areas outside the mine area.
			Provincial	Will affect the NW and Copperbelt Provinces.
			National	Will affect the whole of Zambia.
			International	Will affect other countries.
6.	Significance of Impact	What is the severity of the impact, either positive or negative?	Very High	Very high impact.
			High	High impact.
			Moderate	Moderate impact.
			Low	Little impact.
7.	Further Studies	Are further studies required to assess the significance of the impact?	1.	Requires detailed assessment & specialist studies.
			2.	Requires detailed assessment.
			3.	Requires further assessment.
			4.	Unlikely to require further assessment.
			5.	Further assessment not required.

Environmental impacts are addressed by mine component. These are:

1. Open Pits;
2. Waste Rock Dumps;
3. Plant area, ROM Pad and processing facilities, including:
    - Ore crushing and transfer, and
    - Concentrator.
4. Tailings Storage Facility;
5. Lumwana East River Diversion system;
6. Workshop area;
7. Transport infrastructure;
8. Waste management, including:
    - Industrial waste,
    - Hazardous waste, and
    - Medical waste.
9. Materials Handling and Storage, including:
    - Mine stores, and
    - Fuel and hazardous materials.
10. Concentrate transport; and
11. Construction activities.

The environmental aspects and issues for the Project, based on the mine component of the Project are described in Table D-2, assigning a ranking and characterisation of risk as described in Table 1.

Table D-2: Environmental Aspects and Impacts

ENVIRONMENTAL ASPECT/ISSUE	ITEM NO.	POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL IMPACT CHARACTERISATION						
			Positive / Negative Impact	Likelihood of Impact Occurring	Timing of Impact	Duration of Impact	Extent of Impact	Significance of Impact	Further Impact Study
1. OPEN PITS									
1.1 PRE-CONSTRUCTION PHASE									
Site clearance.	1	Loss of terrestrial flora including rejuvenating miombo woodland and riparian forest.	Negative	Certain	Pre-mining	Permanent	Project Area	High	4
	2	Loss of natural habitat for small mammals, birds and insects.	Negative	Certain	Pre-mining	Permanent	Project Area	High	4
Air quality.	3	Air pollution due to airborne dust generated from the operation of heavy plant equipment used in land clearance.	Negative	Certain	Pre-mining	Short-term	Project Area	Low / Moderate	3
Surface water quality.	4	Contamination of surface water with solids resulting from soil erosion during site clearance.	Negative	Possible	Pre-mining	Short-term	Project Area	Moderate	5
	5	Contamination of surface water with diesel, oil and/or grease from equipment washing and servicing.	Negative	Possible	Pre-mining	Short-term	Project Area	Moderate	4
	6	Contamination of surface water and/or soil due to diesel spill.	Negative	Possible	Pre-mining	Short-term	Project Area	High	4
	7	Contamination of surface water and/or soil due to the accidental release of fuel and oil.	Negative	Possible	Pre-mining	Short-term	Project Area	Moderate / High	4
Public safety.	8	Danger to public resulting from inadvertent access into site clearance areas.	Negative	Possible	Pre-mining	Short-term	Project Area	Low / Moderate	5
1. OPEN PITS									
1.2 OPERATIONAL PHASE									
Surface water quality.	9	Contamination of Lumwana East River from discharging dirty water pumped from the open pit sumps.	Negative	Possible	Near Future	Medium-term	Project Area	Moderate	4

ENVIRONMENTAL ASPECT/ISSUE	ITEM NO.	POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL IMPACT CHARACTERISATION						
			Positive / Negative Impact	Likelihood of Impact Occurring	Timing of Impact	Duration of Impact	Extent of Impact	Significance of Impact	Further Impact Study
	10	Contamination of surface water from effluent discharged from open pit workshops.	Negative	Possible	Near Future	Short-term	Project Area	Moderate	4
Surface water quality.	11	Contamination of water and soil from inappropriate waste disposal practices.	Negative	Possible	Near Future	Short-term	Project Area	Moderate	4
	12	Contamination of water and/or soil from accidental release of hydraulic fluid, oil or fuel.	Negative	Probable	Near Future	Short-term	Project Area	Moderate	4
Soil.	13	Contamination of soil from service, repair or maintenance of mine plant.	Negative	Possible	Near Future	Short-term	Project Area	Low / Moderate	4
Air quality.	14	Generation of airborne dust from the movement of haul trucks and other heavy equipment, ore handling and open pit blasting.	Negative	Certain	Start of Mining	Medium-term	Project Area	Low / Moderate	3
Groundwater	15	Lowering of water table in vicinity of open pits due to mine dewatering.	Negative	Certain	Start of Mining	Medium to Long-term	Project Area	Low / Moderate	4
1. OPEN PITS **1.3 DECOMMISSIONING AND CLOSURE**									
New water resource.	16	Flooding of Malundwe and Chimiwungo open pits by natural recharge.	Positive	Certain	Mid-future	Permanent	Project Area	High	4
Surface water quality.	17	Contamination of water in flooded pits with heavy metals.	Negative	Possible	Mid-future	Long-term	Project Area	High	3
Slope stability.	18	Danger to general public from pit wall instability.	Negative	Possible	Mid-Distant Future	Long-term	Project Area	High	3
2. WASTE ROCK DUMPS **2.1 DEVELOPMENT PHASE**									
Site clearance.	19	Loss of terrestrial flora including rejuvenating miombo woodland and riparian forest.	Negative	Certain	Pre-mining	Medium / Long-term	Project Area	High	4

ENVIRONMENTAL ASPECT/ISSUE	ITEM NO.	POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL IMPACT CHARACTERISATION						
			Positive / Negative Impact	Likelihood of Impact Occurring	Timing of Impact	Duration of Impact	Extent of Impact	Significance of Impact	Further Impact Study
	20	Loss of natural habitat for small mammals, birds and insects.	Negative	Certain	Pre-mining	Medium / Long-term	Project Area	High	3
Surface water quality.	21	Contamination of surface water with solids resulting from soil erosion and runoff during site clearance.	Negative	Possible	Pre-mining	Short-term	Project Area	Moderate	5
Public safety.	22	Danger to public resulting from inadvertent access into area of dumping operations.	Negative	Possible	Pre-mining	Short-term	Project Area	Low / Moderate	5
2. WASTE ROCK DUMPS **2.2 OPERATIONAL PHASE**									
Surface water quality.	23	Contamination of surface water due to runoff and erosion of dump walls.	Negative	Possible	Start of Mining	Medium / Long-term	Project Area	Low / Moderate	5
	24	Contamination of water and/or soil from inappropriate waste disposal practices.	Negative	Possible	Near Future	Short-term	Project Area	Moderate	4
Groundwater quality.	25	Contamination of groundwater due to ARD seepage through base of dumps.	Negative	Unlikely	Near-future	Medium / Long-term	Project Area	High	3
Air quality.	26	Air pollution due to airborne dust generated from the movement of haul trucks and other heavy equipment.	Negative	Certain	Start of Mining	Medium-term	Project Area	Low / Moderate	3
Public safety.	27	Danger to public resulting from inadvertent access into area of dumping operations.	Negative	Possible	Near Future	Medium-term	Project Area	Low / Moderate	5
Heritage conservation.	28	Burial of archaeological sites / rock engravings at Malundwe OB 1	Negative	Certain	Start of Mining	Permanent	Project Area	Very High	2
Noise.	29	Noise nuisance to inhabitants of villages straddling T5 highway from haul trucks and dozers operating on Chimiwungo overburden dumps.	Negative	Probable	Start of Mining	Medium-term	Project Area	Moderate	3

ENVIRONMENTAL ASPECT/ISSUE	ITEM NO.	POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL IMPACT CHARACTERISATION						
			Positive / Negative Impact	Likelihood of Impact Occurring	Timing of Impact	Duration of Impact	Extent of Impact	Significance of Impact	Further Impact Study
3. PLANT AREA, ROM PAD & PROCESSING FACILITIES									
3.1 CONSTRUCTION PHASE									
Site clearance.	30	Loss of terrestrial flora including rejuvenating miombo woodland and riparian forest.	Negative	Certain	Pre-mining	Medium / Long-term	Project Area	High	4
	31	Loss of natural habitat for small mammals, birds and insects.	Negative	Certain	Pre-mining	Medium / Long-term	Project Area	High	4
Surface water quality.	32	Contamination of surface water with solids resulting from soil erosion and runoff during clearance.	Negative	Possible	Pre-mining	Short-term	Project Area	Moderate	5
3. PLANT AREA, ROM PAD & PROCESSING FACILITIES									
3.2 ORE CRUSHING & TRANSFER - OPERATIONAL PHASE									
Air quality.	33	Generation of airborne dust from ore stockpile, crushing circuit and bulk ore transfer points.	Negative	Certain	Start of Mining	Medium-term	Project Area	Low / Moderate	5
Surface water quality.	34	Contamination of surface water and/or soil from silt in runoff from ROM pad.	Negative	Possible	Start of Mining	Medium-term	Project Area	Moderate	4
3. PLANT AREA, ROM PAD & PROCESSING FACILITIES									
3.3 CONCENTRATOR - OPERATIONAL PHASE									
Air quality.	35	Air pollution due to blow off of concentrates from stockpiles.	Negative	Possible	Start of Mining	Medium-term	Project Area	Moderate	4
Accidental releases.	36	Contamination of soil and/or water from overflow of oil traps.	Negative	Possible	Near Future	Short-term	Project Area	Moderate / High	4
	37	Contamination of soil and/or water due to spills caused by equipment failure.	Negative	Possible	Near Future	Short-term	Project Area	Moderate	4
	38	Contamination of soil, water and/or air due to accidental spills of reagents or chemicals	Negative	Possible	Near Future	Short-term	Project Area	Moderate / High	4

ENVIRONMENTAL ASPECT/ISSUE	ITEM NO.	POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL IMPACT CHARACTERISATION						
			Positive / Negative Impact	Likelihood of Impact Occurring	Timing of Impact	Duration of Impact	Extent of Impact	Significance of Impact	Further Impact Study
		caused by inadequate, storage, handling or transport.							
	39	Contamination of soil and/or water due to tailings pipeline failure.	Negative	Possible	Near Future	Short-term	Project Area	Moderate	4
Surface water quality.	40	Contamination of water due to contact between storm water and concentrate or tailings in plant area.	Negative	Possible	Near Future	Short-term	Project Area	Moderate	4
General releases.	41	Contamination of soil, water or air due to exposure of concentrate trucks to elements.	Negative	Possible	Near Future	Medium-term	Provincial	Moderate	4
4. TAILINGS STORAGE FACILITY **4.1 CONSTRUCTION PHASE**									
Site clearance.	42	Loss/disturbance of terrestrial flora and/or fauna in miombo fringe woodland..	Negative	Certain	Pre-mining	Medium / Long-term	Project Area	High	4
	43	Loss of natural habitats.	Negative	Certain	Pre-mining	Medium / Long-term	Project Area	High	4
4. TAILINGS STORAGE FACILITY **4.1 OPERATIONAL PHASE**									
Tailings disposal.	44	Loss of aquatic and wetland flora and fauna.	Negative	Certain	Near Future	Medium / Long-term	Project Area	High	4
Air quality.	45	Dust generation from exposed tailings surfaces which may result in water, soil and/or air pollution in the vicinity of the TSF.	Negative	Probable	Start of Mining	Medium-term	Project Area	Low / Moderate	5
Surface water quality.	46	Contamination of surface water due to non-compliance of dam drainage water with statutory limits for effluent discharged to surface waters.	Negative	Possible	Near Future	Medium-term	Project Area	Moderate	4
Groundwater quality.	47	Contamination of groundwater due to seepage of tailings solution and/or ARD	Negative	Unlikely	Near Future	Medium to Long-term	Project Area	High	3

ENVIRONMENTAL ASPECT/ISSUE	ITEM NO.	POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL IMPACT CHARACTERISATION						
			Positive / Negative Impact	Likelihood of Impact Occurring	Timing of Impact	Duration of Impact	Extent of Impact	Significance of Impact	Further Impact Study
		seepage through base of dam.							
Incident/safety.	48	Lumwana Dam wall failure and inundation of Malundwe open pit with tailings.	Negative	Unlikely	Near Future	Medium / Long-term	Project Area	High	4
	49	Danger to general public from fishing or swimming in Lumwana Dam or wading across the diversion channel.	Negative	Certain	Start of Mining	Medium to Long-term	Project Area	Low / Moderate	5
Public/worker health & safety.	50	Radiation exposure from uranium contained in copper tailings.	Negative	Certain	Start of Mining	Permanent	Project Area	Low / Moderate	4
Spills and/or accidental releases.	51	Contamination of soil and/or water due to tailings pipeline leaks or bursts.	Negative	Possible	Near Future	Short-term	Project Area	Low / Moderate	4
Lumwana East River.	52	Reduced downstream river flow during construction and filling of the Lumwana Dam.	Negative	Certain	Pre-mining	Short-term	Regional	High	4
Lumwana East River.	53	Isolation of the upstream and downstream aquatic environments.	Negative	Certain	Pre-mining	Permanent	Project Area	Moderate / High	4
Water resource.	54	Creation of water resource and new aquatic habitat.	Positive	Certain	Start of Mining	Permanent	Project Area	High	5
5. LUMWANA EAST RIVER DIVERSION **5.1 CONSTRUCTION PHASE**									
Site clearance.	55	Loss of terrestrial and aquatic flora and fauna.	Negative	Certain	Pre-mining	Permanent	Project Area	High	4
	56	Loss of terrestrial and aquatic natural habitats.	Negative	Certain	Pre-mining	Permanent	Project Area	High	4
Public safety.	57	Danger from inadvertent access by public into construction area.	Negative	Possible	Pre-mining	Short-term	Project Area	Low / Moderate	5
5. LUMWANA EAST RIVER DIVERSION **5.2 OPERATIONAL PHASE**									
	58	Erosion and blockage or partial blockage of the diversion channel resulting in flooding of the Malundwe open pit.	Negative	Unlikely	Near Future	Short-term	Project Area	Moderate	4

ENVIRONMENTAL ASPECT/ISSUE	ITEM NO.	POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL IMPACT CHARACTERISATION						
			Positive / Negative Impact	Likelihood of Impact Occurring	Timing of Impact	Duration of Impact	Extent of Impact	Significance of Impact	Further Impact Study
6. PLANT AREA WORKSHOP									
6.1 OPERATIONAL PHASE									
Surface water quality.	59	Contamination of surface water due to carry over of oil with storm water into site drainage system.	Negative	Possible	Near-future	Short-term	Project Area	Moderate / High	4
Surface water quality.	60	Contamination of water due to poor housekeeping, handling spills etc. resulting in contamination of runoff.	Negative	Possible	Near-future	Short-term	Project Area	Moderate / High	4
Soil.	61	Contamination of soil due to inadequate handling and storage of new & used oil.	Negative	Possible	Near-future	Short-term	Project Area	Moderate / High	4
	62	Contamination of soil due to inadequate handling and storage of new and used batteries.	Negative	Unlikely	Near-future	Short-term	Project Area	Moderate / High	4
Spills and/or accidental releases.	63	Contamination of soil and water due to accidental releases of oils.	Negative	Possible	Near-future	Short-term	Project Area	Moderate / High	4
7. TRANSPORT INFRASTRUCTURE									
7.1 OPERATIONAL PHASE									
Spills and/or accidental releases.	64	Contamination of soil, air or water due to accidental release or spill of chemicals, acid, organic solvent, reagents, fuel, oil or concentrate due to inadequate transport procedures.	Negative	Possible	Near-future	Short-term	Project Area	High	4
	65	Contamination of soil, water and/or air as a result of accidental releases due to accidents caused by defective or damaged infrastructure.	Negative	Unlikely	Near-future	Short-term	Project Area	High	4
Air quality.	66	Air pollution due to dust emissions from vehicles and trucks operating on dirt roads and in the plant area.	Negative	Certain	Start of Mining	Medium-term	Project Area	Low / Moderate	4

ENVIRONMENTAL ASPECT/ISSUE	ITEM NO.	POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL IMPACT CHARACTERISATION						
			Positive / Negative Impact	Likelihood of Impact Occurring	Timing of Impact	Duration of Impact	Extent of Impact	Significance of Impact	Further Impact Study
8. WASTE MANAGEMENT **8.1 INDUSTRIAL - OPERATIONAL PHASE**									
Industrial waste.	67	Unnecessary accumulation of scrap metals and materials that can be sold, reused or recycled.	Negative	Possible	Near-future	Medium-term	Project Area	Low / Moderate	4
8. WASTE MANAGEMENT **8.2 HAZARDOUS - OPERATIONAL PHASE**									
Hazardous waste.	68	Contamination of soil and/or water due to inadequate handling, storage and/or disposal of hazardous waste.	Negative	Possible	Near-future	Medium-term	Project Area	High	4
8. WASTE MANAGEMENT **8.3 MEDICAL - OPERATIONAL PHASE**									
Medical waste.	69	Contamination of soil, surface and/or groundwater due to inadequate disposal of medical waste from mine clinic.	Negative	Possible	Near-future	Medium-term	Project Area	High	4
9. MATERIAL HANDLING AND STORAGE **9.1 HYDROCARBONS AND HAZARDOUS MATERIALS**									
Spills and/or accidental releases.	70	Contamination of soil, surface water and/or groundwater due to fuel spills	Negative	Possible	Near-future	Short-term	Project Area	High	4
	71	Contamination of soil, water and/or air due to spills or greases, oils and chemicals during handling and storage.	Negative	Possible	Near-future	Short-term	Project Area	Moderate / High	4
Handling spills and leaks.	72	Contamination of soil and/or water due to handling spill or leak/rupture of fuel tank/tanker.	Negative	Possible	Near-future	Short-term	Project Area	High	4
	73	Contamination of water due to untreated	Negative	Possible	Near-	Medium-	Project	Moderate /	4

ENVIRONMENTAL ASPECT/ISSUE	ITEM NO.	POTENTIAL ENVIRONMENTAL IMPACT	ENVIRONMENTAL IMPACT CHARACTERISATION						
			Positive / Negative Impact	Likelihood of Impact Occurring	Timing of Impact	Duration of Impact	Extent of Impact	Significance of Impact	Further Impact Study
		runoff from fuel storage area entering site drainage system.			future	term	Area	High	

Appendix E

Environmental Management Plan

ENVIRONMENTAL MANAGEMENT PLAN

The purpose of this Environmental Management Plan (EMP) is to ensure that environmental aspects, impacts and thus risks for the Lumwana Copper Project are identified throughout all phases of the Project.

Management actions and timeframes are assigned for each of the aspects.

The EMP will provide a mechanism to ensure compliance with regulatory legislation, standards, guidelines and procedures.

It will be updated annually and compliance against commitments reported through annual reporting mechanisms to government.

Table E.1 identifies the management actions.

Table E-1: Environmental Management Plan

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
1. OPEN PITS					
1.1 PRE-CONSTRUCTION PHASE					
Removal of commercial timber.	To ensure that the timber resource is not wasted and its commercial value is realised.	1	ECV will liaise with the Provincial Forestry Officer in the Ministry of Environment & Natural Resources to have the commercial timber (if any)at the Malundwe and Chimiwungo open pit sites surveyed and valued.	Prior to disturbance	Prior to construction
		2	ECV will engage a timber merchant to selectively fell and remove all commercial timber from the open pit sites.	Prior to disturbance	Prior to construction
Stripping and storing of vegetation and topsoil.	To provide organic material and soil to assist in rehabilitation of the mine site.	3	The mine will in so far as it is practicable to do so, strip and remove vegetation and topsoil from the open pit, perimeter and haul road areas to a dedicated storage area for use in future rehabilitation.	Start of clearing activities	Ongoing
Releases to surface water.	To prevent contamination of water as a result of soil erosion.	4	Vegetation and topsoil will only be stripped immediately prior to the commencement of mining operations.	Prior to disturbance	Ongoing
		5	Storm water cut-off drains will be constructed around the perimeter of the open pit and silt traps will be constructed across all streams flowing from open pit areas to settle solids in surface runoff.	Year -1	Ongoing
	To prevent the contamination of water as a result of washing and servicing of mine equipment.	6	Heavy equipment wash-bays equipped with impervious surfaces and containment to capture effluent from washing operations will be constructed at the open pit workshops.	Year -1	Ongoing
		7	Hydrocarbon traps will be installed in the workshop drainage system to treat effluent prior to release to the mine surface drainage.	Year -1	Ongoing
Soil Contamination.	To prevent contamination of soils at the open pit fuelling station.	8	Bunding and impervious containment will be provided at the fuelling station with 110% of the largest tank capacity volume.	Year -1	Ongoing
Public safety.	To prevent inadvertent access by the public into work areas.	9	ECV will inform the public of dangers of entering construction areas through public consultation, liaison with local community leaders, display of notices in residential areas and display of warning signs.	Year -1	Ongoing

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
Accidental releases.	To prevent contamination of surface water and soil as a result of accidental releases of fuel and oil.	10	ECV will develop and implement emergency response procedures which will specify the steps to be taken in the event of a spill of fuel or oil.	Prior to construction	Ongoing
1. OPEN PITS **1.2 OPERATIONAL PHASE**					
Releases to surface water.	To prevent contamination of water as a result of pumping dirty water from the open pit into the Lumwana East River	11	Sump water pumped from the open pit will be pumped to settlement ponds where water will be re-used for dust suppression. Excess water will be discharged once discharge requirements are met.	Start of dewatering	Ongoing
	To prevent contamination of water as a result of operations at the open pit fuel and lube bay.	12	Hydrocarbon traps will be regularly monitored and emptied to prevent overflowing.	Year 1	Ongoing
		13	Residue from the hydrocarbon traps will be stored in a dedicated area awaiting disposal at an approved site. Hydrocarbon trap supernatant will be integrated into the waste hydrocarbon recycling programme.	Year 1	Ongoing
Soil Contamination.	To prevent contamination of soils at the workshop.	14	The service, repair and maintenance of open pit equipment will be restricted to dedicated areas specifically designed for the purpose.	Year 1	Ongoing
Accidental releases.	To prevent contamination of soil and water caused by an accidental release of fuel or oil.	15	All open pit equipment using hydraulic fluid, oil, fuel or any other substance that has the potential to contaminate surface water, groundwater or soil if released into the environment will be subject to a preventative maintenance programme.	Year 1	Ongoing
		16	Procedures laid down in the Emergency Response Plan will be followed in the event of a spill.	Year 1	Ongoing
Releases to air.	To control/minimise the generation of dust from the movement of haul trucks and other heavy equipment on the open pit haul roads.	17	Haul roads will be routinely sprayed with water in order to suppress dust during open pit operations.	Year 1	Ongoing
	To minimise dust generation from ore handling.	18	Transient ore stockpiles and the ROM pad will be routinely sprayed with water to suppress dust.	Year 1	Ongoing
Releases to air	To assess the potential impact of blasting on air quality outside the open pit perimeter.	19	Dust emissions from blasting will be visually assessed to determine whether or not dust blow beyond the pit perimeter is an issue of concern. If observations indicate that dust is a nuisance, an ongoing monitoring programme will be implemented to quantify	Year 1	Ongoing

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
	To assess the impact, if any, of dust emissions from open pit operations on the local community.	20	A complaints register will be set up. All complaints will be investigated to determine the cause and identify appropriate corrective action.	Year 1	Ongoing
Pit slope stability.	To prevent slope failure as a result of slope water pressure, erosion, overbreak and/or inadequate slope design	21	Erosion protection/control measures and stormwater management infrastructure such as perimeter drainage channels, bund walls and perimeter slope profile will be monitored and maintained to minimise the inflow of water into the pit.	Year 1	Ongoing
		22	The pit walls will be depressurised by pumping from perimeter wells.	Year 1	Ongoing
		23	The pit will be de-watered to prevent build-up and accumulation of water.	Year 1	Ongoing
		24	Safe and efficient blasting practices will be practised at final pit limits.	Year 1	Ongoing
Waste generation.	To prevent soil and water contamination as a result of inappropriate waste disposal practices.	25	Waste generated from the repair, maintenance or service of open pit equipment will handled, stored and disposed of according to ECV's Waste Management strategy.	2005	Closure
		26	Silt settled in the open pit sump during the wet season will be removed as necessary during the dry season by hydro or mechanical means to free up capacity for water to accumulate at the bottom of the pit.	2005	Ongoing
2. WASTE ROCK DUMPS					
2.1 DEVELOPMENT PHASE					
Removal of commercial timber.	To ensure that the timber resource is not wasted and its commercial value is realised.	27	ECV will liaise with the Provincial Forestry Officer in the Ministry of Environment & Natural Resources to have the commercial timber (if any) at overburden dump sites surveyed and valued.	Prior to disturbance	Prior to construction
		28	ECV will engage a timber merchant to selectively fell and remove all commercial timber from the waste rock dump sites.	Prior to disturbance	Prior to construction

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
Stripping and storing of vegetation and topsoil.	To provide organic material and soil to assist in rehabilitation of the mine site.	29	The mine will in so far as it is practicable to do so, strip and remove vegetation and topsoil from the overburden dump sites and access haul road areas to a dedicated storage area.	Start of clearing activities	Ongoing
Releases to surface water.	To prevent contamination of water as a result of soil erosion.	30	Vegetation and topsoil will only be stripped from specified dumping areas 12 months in advance of dumping operations.	Start of clearing activities	Ongoing
		31	Perimeter storm drains will be constructed around all waste rock dumps to collect and manage surface runoff.	Year -1	Ongoing
Public safety.	To prevent inadvertent access by the public into work areas.	32	ECV will inform the public of dangers of entering construction areas through public consultation, liaison with local community leaders, display of notices in residential areas and display of warning signs.	Year -1	Ongoing
	To prevent contamination of water (Lumwana East River) as a result of runoff from west wall of overburden dump.	33	A series of silt traps and a final collection pond will be constructed adjacent to OB1 toe drain.	2005	2005
		34	Clear water from the silt traps will be pumped to discharge into the Lumwana East River.	2005	Ongoing
2. WASTE ROCK DUMPS **2.1 OPERATIONAL PHASE**					
Releases to surface water.	To control runoff and sediment from dump walls and minimise erosion.	35	ECV will develop a dumping strategy whereby weathered overburden materials are identified and dumped in central areas of the dump. More competent waste materials will be used to construct outer walls and to dress dump slopes.	Year 1	Ongoing
		36	Dump walls will be constructed with overall slope angles of 20 degrees with the overall intent of inter-berm slope angles of 1:3, 10 metre wide berms and 40 metre vertical lifts.	Year 1	Ongoing
		37	Waste rock dumps will be of terrace construction i.e. no end-dumping will be carried out.	Year 1	Ongoing
		38	Dumps construction will be regularly monitored to check that construction is as per design.	Year 1	Ongoing
		39	All silt traps and dump perimeter drains will be regularly monitored and maintained. Silt traps and drains will be cleared of solids in October prior to the start of the wet season and as necessary. Solids removed from the silt traps will be placed in zones within the waste rock dumps.	Year 1	Ongoing

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
	To monitor and assess the quality of dump wall surface runoff and any seepage.	40	The quality of dump wall runoff and seepage (if any) will be monitored as specified in the Environmental Monitoring Program.	Year 1	Ongoing
Releases to air.	To control/minimise the generation of dust from the movement of haul trucks and other heavy equipment on the overburden dumps.	41	Active areas of the overburden dumps will be routinely sprayed with water in order to suppress dust during tramming and placement of waste material.	Year 1	Ongoing
Waste generation.	To prevent contamination of soil and water as a result of inadequate handling and disposal of non-hazardous waste.	42	Non-hazardous waste will not be stored on the waste rock dumps unless done in accordance with the ECV Waste Management Strategy and then only in dedicated areas.	Year 1	Closure
Public safety.	To prevent inadvertent access by the public into dumping areas.	43	ECV will inform the public of dangers of entering dumping areas through public consultation, liaison with local community leaders, display of posters in villages and erection of warning signs.	Prior to disturbance	Ongoing
Progressive re-vegetation of dump walls and upper surfaces.	To ensure revegetation is carried out effectively and efficiently using best available practices to produce a sustainable vegetation cover, better stabilise slopes, improve visual aesthetics and minimise re-vegetation activities at closure.	44	ECV will develop and implement a progressive dump re-vegetation programme focusing on the establishment of a sustainable indigenous vegetation cover in keeping with the surrounding area.	Year 1	Ongoing
Archaeological sites on the Lumwana East River.	To protect archaeological sites from unauthorised exploitation, excavation or damage.	45	Following recommendations made in a report by the National Heritage Conservation Commission (NHCC) ECV will fund the removal of rocks with pre-historic pock marks and incised strokes to an NHCC approved location for display.	Prior to disturbance	Prior to disturbance
Releases to surface water.	To control surface runoff and prevent erosion of dump walls and silting up of perimeter drains.	46	ECV will develop a strategy and engineer a plan to manage surface runoff from the Chimiwungo dumps. In practice, the upper surfaces of OB4 and OB5 will be contoured and profiled such that all surface runoff flows into the perimeter drains in a controlled	2010	2013

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
Noise.	To minimise noise levels and noise nuisance to inhabitants of villages straddling the T5 highway resulting from the operation of haul trucks and dozers on Chimiwungo overburden dumps.	47	A minimum distance of 750 metres will be maintained between the southern edge of the overburden dumps and existing villages along the T5 highway.	Year 6	Ongoing
		48	Where practicable dump construction will be sequenced to provide a waste rock noise barrier between dumping operations and affected villages.	Year 6	Ongoing
		49	If physical audio observations indicate that noise is a nuisance, an ongoing 24 hr monitoring programme will be implemented to quantify noise levels and the results used to develop appropriate mitigation measures.	Year 6	Ongoing
		50	A noise complaints register will be set up. All complaints will be investigated to determine the cause and identify appropriate corrective action.	Year 1	Ongoing
3. PLANT AREA, ROM PAD & PROCESSING FACILITIES **3.1 CONSTRUCTION PHASE**					
Removal of commercial timber.	To ensure that the timber resource is not wasted and its commercial value is realised.	51	ECV will liaise with the Provincial Forestry Officer in the Ministry of Environment & Nat. Res. to have the commercial timber (If any) in the plant and ROM pad areas surveyed and valued.	Prior to disturbance	Prior to disturbance
		52	ECV will engage a timber merchant to selectively fell and remove all commercial timber from the plant ROM pad areas.	Prior to disturbance	Prior to disturbance
Stripping and storing of vegetation and topsoil.	To provide organic material and soil to assist in rehabilitation of the mine site.	53	The mine will in so far as it is practicable to do so, strip and remove vegetation and topsoil from the plant and ROM pad areas to a dedicated storage area.	Prior to disturbance	Prior to disturbance
Releases to surface water.	To prevent contamination of water as a result of soil erosion.	54	Storm water cut-off drains will be constructed around the perimeter of the plant and ROM pad area. The storm water drains will discharge into the Lumwana TSF or water storage dam.	Year 1	Ongoing

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
Management of contractors.	To prevent the general disturbance of the environment through waste generation, excavation, tree felling, unauthorised construction etc.	55	Environmental management requirements will be incorporated into all contract documents between the contractor and ECV.	2005	Ongoing
		56	The principal contractor will submit a construction environmental management plan to be approved by the HSE Manager. ECV will provide relevant information and HSE policies to the contractor to assist in preparation of this plan.	Start of Contract	Start of Contract
		57	Contractors will be monitored and audited against HSE requirements specified in the contract.	Start of Contract	End of contract
		58	The principal contractor (all employees and sub-contractors) will attend an induction on before being allowed on site.	Start of Contract	Start of Contract
3. PLANT AREA, ROM PAD & PROCESSING FACILITIES **3.2 OPERATIONAL PHASE**					
Air Quality	To minimise dust emissions	59	Water sprinkler systems will operate in the crushing circuit and at bulk ore transfer locations to suppress dust.	Year 1	Ongoing
Releases to air.	To assess the performance of dust suppression systems.	60	Air quality control equipment will be installed in critical areas and an air quality monitoring programme implemented to assess system performance.	Year 1	Ongoing
Releases to surface water.	To prevent soil and water contamination due to silt in surface runoff from the ROM pad.	61	Surface runoff from the ROM pad will be collected in a silt trap/sedimentation pond. Clean water will be returned to the plant or discharged into the Lumwana water storage dam or the TSF. The sedimentation pond will be regularly maintained.	Year 1	Ongoing
3. PLANT AREA, ROM PAD & PROCESSING FACILITIES **3.3 CONCENTRATOR - OPERATIONAL PHASE**					
Releases to air.	To prevent air pollution due to blow off of concentrates as a result of exposure to wind.	62	Copper concentrate will only be stored in designated covered and bunded areas i.e. concentrate storage shed	Year 1	Ongoing

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
Spills and/or accidental releases.	To prevent contamination of soil and water resulting from overflow of oil traps.	63	Hydrocarbon traps installed around machinery in the mill to capture spills will be regularly serviced and maintained. Oily residues will be stored in drums in a designated area awaiting collection by recycling company.	Year 1	Ongoing
	To prevent contamination of soil and water due to spillage caused by equipment failure.	64	Process tanks, pipes, pumps and other equipment will be subject to a preventative maintenance programme aimed at reducing spill in the event of equipment failure. Equipment and containment areas will regularly inspected. Inspection reports will be used to	Year 1	Ongoing
	To prevent contamination of soil, water or air resulting from accidental spills or releases of process reagents or chemicals caused by inadequate handling, storage or transport thereof.	65	Handling and storage of reagents will be done according to procedures on materials handling.	Year 1	Ongoing
		66	Process reagents and chemicals will be moved around the site in accordance with the materials handling procedures.	Year 1	Ongoing
		67	Regular inspections of reagent storage and containment areas, and containers will be conducted.	Year 1	Ongoing
Spills and/or accidental releases.	To prevent contamination of soil, water or air resulting from accidental spills or releases of process reagents or chemicals caused by inadequate handling, storage or transport thereof.	68	In the event of a spill, spilled materials will be removed and the area cleaned-up as soon as possible. If appropriate, soil and/or water samples will be taken to confirm effectiveness of the clean-up.	Year 1	Ongoing
		69	An inventory control procedure will be implemented to track and document the flow of process chemicals and reagent through the storage facility.	Year 1	Ongoing
Spills and/or accidental releases.	To minimise the risk of tailings pipeline failure between the tailings thickener and the tailings dam or Malundwe open pit and to contain a pipeline breach.	70	Tailings pipelines and pumps will be subject to a preventative maintenance programme. The programme will include regular inspections of tailings slurry infrastructure, testing and reporting of malfunctions, defects or operational problems and spare parts	Year 1	Ongoing
		71	Visual leak detection inspections will be conducted along the entire pipeline on a daily basis.	Year 1	Ongoing
		72	In the event of a spill, spill response procedures and measures will be followed.	Year 1	Ongoing

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
		73	The tailings disposal pipeline will be placed in a channel to collect spillages. The channel will drain under gravity into a bunded containment area or directly into the TSF.	Year 1	Ongoing
Releases to surface water.	To prevent the contamination of water resulting from the contact between concentrate or tailings and stormwater i.e. to prevent carry over of tailings or concentrate into plant site drainage system.	74	Plant spills of concentrate and/or tailings will be collected in sumps and pumped back to the process.	Year 1	Ongoing
			Stormwater drains will be kept clear of debris to prevent overflow of drains into tailings and concentrate areas.	Year 1	Ongoing
Water consumption.	To control, optimise and efficiently utilise raw water in the mill and concentrator.	75	Water consumption in the mill and concentrator (major streams) will be monitored. Water input and output will be recorded in order to monitor plant water throughput.	Year 1	Ongoing
4. TAILINGS STORAGE FACILITY **4.1 CONSTRUCTION PHASE**					
Removal of commercial timber.	To ensure that the timber resource is not wasted and its commercial value is realised.	76	ECV will liaise with the Provincial Forestry Officer in the Ministry of Environment & Natural Resources to have the commercial timber (if any)at the TSF surveyed and valued.	Prior to disturbance	Prior to construction
		77	ECV will engage a timber merchant to selectively fell and remove all commercial timber from the TSF area.	Prior to disturbance	Prior to construction
Lumwana East River Flow.	To ensure that a normal dry season flow volume is maintained in the Lumwana East River throughout the construction of the Lumwana Dam and dam filling so as to minimise negative downstream impacts on water users and natural resources.	78	A sufficient volume of water will be pumped from the Lumwana East River above Lumwana Dam into a pipeline and/or the diversion channel to ensure a minimum flow volume (normal dry season) is maintained in the river downstream of the project.	Year 1	Ongoing
		79	The flow volume of the Lumwana East River immediately downstream of the project will be monitored monthly during the construction phase.	Year 1	Ongoing
4. TAILINGS STORAGE FACILITY **4.2 OPERATIONAL PHASE**					

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
Releases to air.	To prevent dust generation from exposed tailings surfaces at the open end tailings discharge point, which may result in localised air pollution and soil contamination adjacent to the tailings storage facility.	80	Re-vegetation of any tailings surface will be conducted following the cessation of tailings deposition.	Year 15	Ongoing
		81	Dust levels will be monitored as specified in the Environmental Monitoring Program and the Health and Safety Management Plan.	Year 1	Ongoing
Seepage to surface water.	To prevent the contamination of the Lumwana East River due to seepage of effluent from the TSF.	82	The quality and volume of discharge from the tailings storage facility will be regularly monitored.	Year 1	Ongoing
Spills and/or accidental releases.	To prevent contamination of soil and water and accumulation of tailings along the pipeline due to leaks, spills and accidental releases.	83	Tailings spill material will be picked up and placed in the tailings dam.	Year 1	Ongoing
5. LUMWANA EAST RIVER DIVERSION					
5.1 CONSTRUCTION PHASE					
Removal of commercial timber.	To ensure that the timber resource is not wasted and its commercial value is realised.	84	ECV will liaise with the Provincial Forestry Officer in the Ministry of Environment & Nat. Res. to have the commercial timber (if any) In areas affected by the Lumwana East River diversion tunnel system surveyed and valued.	Prior to disturbance	Prior to construction
Removal of commercial timber.	To ensure that the timber resource is not wasted and its commercial value is realised.	85	ECV will engage a timber merchant to selectively fell and remove all commercial timber affected by the diversion tunnel system.	Prior to disturbance	Prior to construction
Stripping and storing of vegetation and topsoil.	To provide organic material and soil to assist in rehabilitation of the mine site.	86	The mine will in so far as it is practicable to do so, strip and remove vegetation and topsoil from the area affected by the diversion tunnel system to a dedicated storage area.	Prior to disturbance	Prior to construction
Public safety.	To prevent inadvertent access by the public into construction areas.	87	ECV will inform the public of dangers of entering construction areas via public consultation, liaison with community leaders, display of posters in villages and erection of warning signs.	Prior to disturbance	Ongoing

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
5. LUMWANA EAST RIVER DIVERSION					
5.2 OPERATIONAL PHASE					
Incident/safety risk.	To prevent possible blockage of the diversion channel resulting in flooding of Malundwe open pits.	88	Monthly inspections of the diversion channel will be made and an inspection record kept at the mine.	Year 1	Ongoing
		89	The Lumwana East River Diversion System will be operated according to the Safe Operating Manual provided by the design engineers.	Year 1	Ongoing
6. PLANT AREA WORKSHOP					
6.1 OPERATIONAL PHASE					
Release to surface water.	Contamination of water due as a result of carry over of oil with stormwater and entry into site drainage network.	90	Washing of mobile equipment and machine parts will be done in designated wash bays equipped with impervious floor and containment. All drainage from wash bays will pass through a hydrocarbon trap prior to release into the site drainage network. Oil traps will be	Year 1	Ongoing
		91	Hydrocarbon traps will be installed in drains at all hydrocarbon handling and storage areas to capture and recover all residues present in site drainage. This will prevent carry over of hydrocarbon with storm water.	Year 1	Ongoing
	Poor housekeeping, handling spills etc.. can result in contamination of surface runoff.	92	Regular inspections of the workshop areas will be conducted as part of a preventative maintenance programme to monitor potential sources of contamination.	Year 1	Ongoing
Release to soil.	Contamination of soil due to inadequate handling and storage of new and used oil.	93	All new and used oil will be stored in accordance with specifications in the Materials Handling Procedure. Key measures include: hydrocarbons to be handled only in designated areas; hydrocarbon handling and storage areas will have impervious surfaces, containment.	Year 1	Ongoing
Release to soil.	Contamination of soil due to inadequate handling and storage of hazardous materials	94	Hazardous materials handling and storage areas will be subject to regular inspection. Inspection results will determine service, maintenance and repair requirements.	Year 1	Ongoing

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
		95	Workshop mechanics and operators will receive training on handling and disposal of hazardous materials. The program will focus on environmental awareness, safe handling procedures, spill reporting and spill response/action.	Year 1	Ongoing
Spills and/or accidental releases.	Contamination of soil and water due to accidental releases of oils.	95	Spills will be handled in accordance with procedures outlined in the Emergency Response Plan. The procedures detail measures to be effected in the event of a spill. These include: people to be notified; emergency equipment to be used; corrective actions;	Year 1	Ongoing
7. TRANSPORT INFRASTRUCTURE					
7.1 OPERATIONAL PHASE					
Spills and/or accidental releases.	To prevent soil, air and water contamination as a result of accidental releases or spills of chemicals, sulphuric acid, organic solvent, reagents, fuel, oils and concentrate due to inadequate transport procedures.	96	The transport of hazardous materials to and from and in and around the mine site will be done in accordance with laid down procedure. Requirements will include: documentation and inventory control through chain-of-custody; emergency response training for spills.	Year 1	Ongoing
Spills and/or accidental releases.	To prevent soil, air and water contamination as a result of accidental releases or spills of chemicals, reagents, fuel, oils and copper concentrate due to inadequate transport procedures.	97	Only designated transport routes will be used to transport chemicals, sulphuric acid, organic solvent, reagents, fuel, oil and concentrate.	Year 1	Ongoing
		98	Trucks carrying explosives will be accompanied by an escort and all vehicles will be appropriately flagged.	Year 1	Ongoing
		99	Tarpaulins will be used on open top bulk concentrate transport trucks to provide protection from the elements.	Year 1	Ongoing
		100	Contracts with transport companies will include clauses on Zambian and relevant regional/international standards relating to the transport of hazardous materials. These will cover packaging, appropriate type of vehicle and compatibility of materials that	Year 1	Ongoing
	To prevent soil, air and water contamination as a result of accidental releases due to accidents caused by defective or damaged infrastructure.	101	A preventative maintenance programme will be implemented on all mine roads, bridges, and culverts to ensure that they are kept in good condition. This will minimise the occurrence of accidents caused by defective or damaged infrastructure.	Year 1	Ongoing

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
Releases to air.	To prevent contamination of air due to dust emissions from vehicles and trucks operating on dirt roads and in the plant area.	102	Water spraying will be conducted on all mine dirt roads.	Year 1	Ongoing
8. WASTE MANAGEMENT **8.1 INDUSTRIAL – OPERATIONAL PHASE**					
Industrial waste generation.	To minimise production of industrial waste - Scrap metal, empty containers etc will be generated continuously from normal mine operations.	103	Industrial waste will be disposed of according to the company's Waste Management Policy and Scrap Sales Procedures.	Year 1	Ongoing
	Scrap metals and equipment should be recycled to reduce the amount of waste generated.	104	Secure storage areas for scrap metal and equipment will be identified. Materials will be sorted to assist recovery and reuse/recycling. Scrap metal merchants and used equipment dealers will be encouraged to take away waste materials.	Year 1	Ongoing
	Reusable materials should be reused or re-cycled to reduce the amount of waste generated.	105	Secure storage areas for reusable materials will be identified. Reusable materials include empty drums, timber, etc. These will be reused by the mine, sold or given away.	Year 1	Ongoing
		106	Used tyres will be painted fluorescent colours and used by the mine to mark out the edges of roads, bends and accident black spots.	Year 1	Ongoing
8. WASTE MANAGEMENT **8.2 HAZARDOUS – OPERATIONAL PHASE**					
Hazardous waste generation.	To prevent hazardous waste from contaminating soils and water.	107	Hazardous waste will be stored in a secure area. Storage areas will be contained in bunded areas and have 110% of the largest vessel in the bund as bund capacity. Non-compatible hazardous wastes will be stored at separate sites.	Year 1	Ongoing
8. WASTE MANAGEMENT **8.3 MEDICAL – OPERATIONAL PHASE**					

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
Medical waste generation.	To prevent the contamination of soil, surface water and/or groundwater due to the inadequate disposal of medical waste from the mine clinic.	108	The disposal of medical waste will be done in accordance with the mine's Waste Management Strategy.	Year 1	Ongoing
9. MATERIALS HANDLING AND STORAGE					
9.1 HYDROCARBONS AND HAZARDOUS MATERIALS					
Spills and/or accidental releases.	To prevent fuel spills from contaminating soil, surface water and/or groundwater.	109	Statutory bunding (110% capacity of largest tank in bund as storage capacity) and concrete surfaces will be provided to all fuel storage tanks.	Year 1	Ongoing
		110	In the event of a spill, procedures outlined in the Spill Response Plan will be followed. The procedures include: clean-up action; clean-up materials; and disposal of contaminated soil and clean-up materials.	Year 1	Ongoing
		111	Spills will be dealt with in accordance with the mine's Spills Prevention, Control and Clean-up Plan.	Year 1	Ongoing
Spills and/or accidental releases.	To prevent the spill of oils, greases and chemicals during handling and storage which may result in the contamination of soil and/or water.	112	Spills of oils, grease or chemicals will be immediately cleaned-up in accordance with the site procedures..	Year 1	Ongoing
	To prevent the spill of oils, greases and chemicals during handling and storage which may result in the contamination of soil and/or water.	113	Operators handling or using chemicals and reagents will receive training. Training will focus on potential risks, hazards, safe handling procedures, safety precautions, first aid, emergency response and appropriate disposal procedures.	Year 1	Ongoing
Release of hazardous substances.	To prevent/minimise the risk of chemical spills.	114	Material data sheets will be obtained for all chemical substances used on the mine. The material data sheets will specify hazards, compatibility with other substances and special handling, storage or disposal requirements.	Year 1	Ongoing
Fuel handling spills & leaks.	To prevent the contamination of soil and/or water as a result of a handling spill or leak/rupture of fuel tank.	115	Regular inspections of bunding around fuel tanks will be conducted. Hydrocarbon traps will be regularly maintained and drains kept clean.	Year 1	Ongoing

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
		116	Fuel stocks will be reconciled regularly to identify possible leaks from fuel tanks located below ground.	Year 1	Ongoing
Fuel handling spills & leaks.	To ensure that drainage from fuel storage areas does not directly enter the plant site drainage system without prior treatment and contaminate soil and/or water.	117	Drainage from fuel storage areas will be isolated from the site drainage systems and passed through a hydrocarbon trap prior to release.	Year 1	Ongoing

Appendix F

Environmental Monitoring Program

ENVIRONMENTAL MONITORING PROGRAM

ECV will implement an environmental monitoring program in and around the operational area to monitor environmental performance and compliance with statutory environmental regulations. Environmental monitoring will provide the information for periodic review and alteration of the EMP as necessary ensuring that environmental protection is optimised at all stages of the development. This will ensure that undesirable environmental impacts are detected early and remedied effectively. It will also demonstrate compliance with regulatory requirements.

For the first five years, mining activities are focussed on the Malundwe area, and therefore the monitoring program is focussed in this area. During this first five years, an appropriate baseline monitoring will be developed and implemented at least one year prior to ground disturbing activities in the Chimiwungo area to ensure an adequate database of. This will be reported through the annual update of the EIA

At ECV, the monitoring program will comprise the following aspects:

- Water (ground and surface);
- Land;
- Biology (aquatic and terrestrial);
- Air and noise (includes meteorological conditions);
- Processes and wastes; and
- People and communities, including heritage values.

Environmental monitoring data will be maintained in an electronic data base and Geographical Information system (GIS). This will be the key management tool to monitor historical and current environmental performance as well as environmental compliance.

Table F-1 summarises the monitoring program. It is important to note that SW locations referred to in the monitoring location column are distinct from those undertaken as part of the baseline monitoring program; all past and future monitoring locations will be given a unique identifying number prior to the commencement of construction activities to ensure data is managed adequately.

Table F-1: Environmental Monitoring Program

PROGRAM	DESCRIPTION	MONITORING LOCATION	FREQUENCY	PARAMETERS	COMPLIANCE REQUIREMENTS
WATER					
Surface water quality	Ambient surface water quality – upstream and downstream of the area of disturbance	SW1: Lumwana East River upstream of Lumwana Dam. SW2: Lumwana East River below the confluence with the Malundwe stream (also the proposed Licensed discharge point)	Monthly	pH, EC, TDS, TSS, SO_4, Cu, Fe, Co, Mn, As, U, Ra-226	Key statutory limits that will be adhered to include the Statutory Limits for effluent discharged to surface waters. This is summarised below. Where the World Bank guideline for discharge to surface waters is lower than the Zambian statutory limit the World Bank guideline is shown in brackets. For these parameters ECV is committed to complying with the World Bank guideline. Limits for uranium and radium-226 in effluent discharge to surface waters are taken from the USEPA effluent limitations for drainage from open pits and uranium processing facilities
			6-monthly	Mg, Cl, NO3, NH3, Zn, Ni, Ca, Al, Pb, Cr, Hg, Sb, Se, B, F, Mo, Ag, Ba, Tl, V, Sn	
	Monitoring at key on-site discharge locations.	SW3: surface water runoff from plant and workshop infrastructure. SW4: TSF seepage SW5: Runoff from ROM pad SW6: Runoff from waste dump into TSF SW7: Malundwe stream above the confluence with Lumwana East River	Monthly	pH, EC, TDS, TSS, SO_4, Cu, Fe, Co, Mn, As, U, Ra-226	
			6-monthly	Mg, Cl, NO3, NH3, Zn, Ni, Ca, Al, Pb, Cr, Hg, Sb, Se, B, F, Mo, Ag, Ba, Tl, V, Sn	

Parameter	Statutory Limit / Proposed Standard	Parameter	Statutory Limit / Proposed Standard
PH	6.0 - 9.0	Lead - Pb	0.5 (0.1)
EC	4,300	Chromium - Cr	0.1
TSS	100 (50)	Mercury - Hg	0.002
TDS	3,000	Arsenic - As	0.05
Magnesium - Mg	500	Antimony - Sb	0.5
Chloride - Cl	800	Selenium - Se	0.02
Sulphate - SO_4	1,500	Boron - B	0.5
Nitrates - NO_3-N	50	Fluoride - F	2.0
Ammonium - NH_3-N	10	Molybdenum - Mo	5.0
Iron - Fe	2.0	Silver - Ag	0.1
Copper - Cu	1.5 (0.5)	Barium - Ba	0.5
Zinc - Zn	10 (2.0)	Thallium - Tl	0.5
Nickel - Ni	0.5	Vanadium - V	1.0
Cobalt - Co	1.0	Tin - Sn	2.0
Aluminium - Al	2.5	Uranium - U	4.0
Manganese - Mn	1.0	Radium 226 - Ra	1.11
Cadmium - Cd	0.5 (0.1)		

PROGRAM	DESCRIPTION	MONITORING LOCATION	FREQUENCY	PARAMETERS	COMPLIANCE REQUIREMENTS
Surface water flows	To quantify discharges	SW2, SW3, SW4	A combination of weirs across the Lumwana East River and calculation methods will be utilised to calculate annual loads.	Annual loads of key anlalytes (including Cu, Co, U, Ra-226 will be determined)	To meet statutory discharge requirements.
Groundwater quality and levels	Areas of potential contamination as a result of seepage from locations such as the TSF, plant and workshop.	• 2 groundwater monitoring bores (GWMB) down gradient (and adjacent to concentrate storage area. • 1 GWMB down gradient form plant and workshop area; • 1 GWMB down gradient from laboratory area • 2 GWMB down gradient from TSF (1 near to SW4). • 1 GWMB adjacent to SW2.	Monthly	Levels	No compliance requirements – to monitor impacts and ensure mitigation measures are appropriate.
			Monthly	pH, EC, TDS, TSS, SO_4, Cu, Fe, Co, Mn, As, U, Ra-226	No compliance requirements – to monitor impacts and ensure mitigation measures are appropriate.
			6-monthly	Mg, Cl, NO3, NH3, Zn, Ni, Ca, Al, Pb, Cr, Hg, Sb, Se, B, F, Mo, Ag, Ba, Tl, V, Sn	No compliance requirements – to monitor impacts and ensure mitigation measures are appropriate.

PROGRAM	DESCRIPTION	MONITORING LOCATION	FREQUENCY	PARAMETERS	COMPLIANCE REQUIREMENTS
Biological	Aquatic and terrestrial flora and fauna	Location will be selected in line with the baseline assessment to monitor impacts on biological data	Bi-annual	Selection of parameters to be determined in consultation with relevant regulatory authorities to ensure potential impacts are detected.	Compliance requirements – to minimise impacts and compare to baseline environmental data.
Land	Areas disturbed and rehabilitated	LML-49, entire lease	Updated annually	Will record area disturbed versus area rehabilitated.	No compliance requirements – to manage area disturbed.
	Success of rehabilitation	Plots will be determined once rehabilitation has begun and will include analogue sites in undisturbed areas.	Annual	To be determined, will include: Erosion rates, growth rates, species richness etc.	To meet stable, sustainable landforms at closure.
Air Emissions	Meteorology	Station in compliance with AS 2922 (Australian Standard for siting of monitoring ambient air)	Continuous	• Temperature • Rainfall • Humidity • Wind (speed, direction) • Pressure	No compliance requirements – monitoring of natural conditions to supplement other monitoring including runoff volumes, ambient dust loads and noise levels.

<table>
<tr><th>PROGRAM</th><th>DESCRIPTION</th><th>MONITORING LOCATION</th><th>FREQUENCY</th><th>PARAMETERS</th><th>COMPLIANCE REQUIREMENTS</th></tr>
<tr><td></td><td>Ambient dust</td><td>Locations will be established around the area of disturbance to record ambient dust levels</td><td>Monthly totals</td><td>Total dust levels</td><td rowspan="2">Statutory dust emission limits as detailed in Pollution Control Regulations – Third Schedule
<table>
<tr><th>Parameter</th><th>Emission Limits</th></tr>
<tr><td>Total dust concentration</td><td>50 mg/Nm^3</td></tr>
<tr><td>Heavy metal content in dust-</td><td></td></tr>
<tr><td>- Arsenic (As)</td><td>0.5 mg/Nm^3</td></tr>
<tr><td>- Cadmium (Cd)</td><td>0.05 mg/Nm^3</td></tr>
<tr><td>- Copper (Cu)</td><td>1.0 mg/Nm^3</td></tr>
<tr><td>- Lead (Pb)</td><td>0.2 mg/Nm^3</td></tr>
<tr><td>- Mercury (Hg)</td><td>0.05 mg/Nm^3</td></tr>
<tr><td>Total suspended particles - ambient</td><td>120 μg/m^3 - averaged over 24 hours</td></tr>
</table>
There are no Zambian statutory limits regulating uranium dust in air. Low concentrations of uranium dust in air may occur in the crusher plant or at the tailings storage facility. ECV proposes to adopt USEPA standards for uranium dust concentrations in air.
<table>
<tr><th>Type of Uranium Dust</th><th>Concentration in Air</th></tr>
<tr><td>Uranium Tailings</td><td>253 μg/m^3</td></tr>
<tr><td>Uranium Ore Dust</td><td>18 μg/m^3</td></tr>
</table></td></tr>
<tr><td></td><td>Ambient dust (2)</td><td>At two locations on the site, Hi-Volumetric methodology will be utilised.</td><td>Monthly</td><td>U , Ra-226</td></tr>
<tr><td>Noise</td><td>Ambient and point source</td><td>Nearby residential areas</td><td>Annual</td><td>Survey undertaken annually to record noise levels in comparison to baseline measurements.</td><td></td></tr>
<tr><td>Social</td><td>Population</td><td>Consistent with baseline monitoring program already established</td><td>Bi-annual</td><td>Population numbers and number of dwellings</td><td>To monitor potential increases in the area as a result of the Project.</td></tr>
</table>

PROGRAM	DESCRIPTION	MONITORING LOCATION	FREQUENCY	PARAMETERS	COMPLIANCE REQUIREMENTS
	Traffic	Consistent with baseline monitoring program already established	Bi-annual	Vehicle movements	No compliance requirements – to monitor impacts and ensure mitigation measures are appropriate.

Appendix G

Social Management Plan

SOCIAL MANAGEMENT PLAN

The principal objectives of ECV's Social Management Plan (SMP) are to:

- Maximise local and provincial employment and business opportunities;
- Encourage diversification and movement away from the historical dependence of Zambian business on the mining sector;
- Assist community development by constructing a school, clinic and recreation facilities within the Lumwana Estate;
- Promote sustainable businesses that will survive the eventual closure of Lumwana mine.
- Explain ECV policies on environmental issues to the community and public at large, via the public consultation process.

Table G-1 discusses the key aspects at Lumwana and the objectives and management actions that ECV is committed to.

Table G-1: Social Management Plan

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
1. EMPLOYMENT AND CONDITIONS OF SERVICE					
Local employment.	Local employment is of vital importance in order to optimise and maximise the benefits of the mine for the local economy.	1	ECV will design and implement a local employment strategy that focuses on the employment of people from the Lumwana and Solwezi areas.	Project Start	Mine Closure
		2	ECV is an 'equal opportunity' employer. In practice this means that the best applicants for the jobs will be offered employment.	Project Start	Mine Closure
		3	Locals will be given priority in employment subject to qualifications and experience.	Project Start	Mine Closure
		4	ECV will design and implement a 'non Zambian replacement strategy' to ensure over a reasonable period of time non Zambian employees are replaced by local expertise subject to skills, ability and experience.	Project Start	Mine Closure
		5	ECV will offer its employees salaries and conditions of service commensurate with other mining companies operating in Zambia.	Project Start	Mine Closure
	Improving the quality of labour and employee competency.	6	ECV will implement an active training and development programme for its employees so that they may carry their skills elsewhere if they so wish.	Project Start	Mine Closure
Contractor employment.	Increase competencies and managerial capacity of local contractors.	7	ECV will implement a contractor engagement strategy that ensures local Zambian contractors are employed in preference to foreign contractors subject to their ability and competitiveness to carry out the work.	Project Start	Mine Closure
		8	ECV will develop and implement human resource conditions that must be complied with for awarding contracts to suppliers.	Project Start	Mine Closure
		9	ECV will define conditions and safety standards that its employees and contractors will have to comply with, so as to promote a safer working environment.	Project Start	Mine Closure

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
			These conditions will include HIV/AIDS awareness and prevention campaign		
2. LOCAL ECONOMIC DEVELOPMENT PLAN					
Use of local suppliers. (Zambian registered companies)	To improve business multipliers and reduce unemployment.	10	ECV will implement a procurement strategy that supports local economic development.	Project Start	Mine Closure
Expand opportunities for alternative economic activities to mining in the Lumwana area.	In order to reduce the economic dependency on mining and promote sustainable development independent of the mining sector.	11	ECV through local procurement practices, employment and training strategies will be supportive of local businesses and new businesses.	Project Start	Mine Closure
3. LAND USE AND SETTLEMENT					
Residential Accommodation	To ensure appropriate and suitable accommodation is provided to all employees and contractors	12	ECV supports the establishment of a residential estate with substantial facilities to ensure the long-term welfare of all its personnel is first and foremost.	Project Start	Mine Closure
	To facilitate home ownership	13	Employees will be offered a low interest loan to purchase modern housing in the Lumwana Estate.	Project Start	Mine Closure
Access tracks into Mine Surface Area	To prevent inadvertent access by the general public into hazardous areas.	14	ECV will liaise with the Chief and local community to establish safe routes around the Mine Surface Area.	Project Start	Mine Closure
Demarcation and communication.	Local communities may encroach on the Mine Surface Area for both settlement and livelihood activities. Communities and local stakeholders should be discouraged from using the Mine Surface Area for both settlement and to support their livelihoods.	15	The Mine Surface Area will be clearly demarcated and ECV's land use and settlement strategy communicated to local communities and stakeholders.	Project Start	Mine Closure
		16	ECV will document its strategy on Mine Surface Area land use and settlement.	Project Start	Mine Closure
		17	The Mine Surface Area will be marked on site using beacons and signs, and shown on mine plans.	Project Start	Mine Closure
		18	Mine Surface Area maps, ECV's land use & land	Project	Mine

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
			capability maps, and settlement policy will be shared with Chief Mukumbi, the general community and local government officials through public consultation.	Start	Closure
The protection of communities from the direct hazards of mining operations.	Mine operations can be hazardous to people and the Zambian law states that the public be excluded from hazardous areas. The public must not be allowed to approach within 100 metres of the plant and mine activities.	19	Ensure that all hazardous areas are mapped and clearly marked on site.	Project Start	Mine Closure
		20	Provide general information and raise awareness about mine hazards through public consultation process and workshops.	Project Start	Mine Closure
		21	Evict cultivators from hazardous areas.	Project Start	Mine Closure
Utilisation of surface water by local communities.	Surface water on the Mine Surface Area includes the East Lumwana River, its tributary streams, wetlands (dambos), water dams and tailings dams. These water bodies should be utilised in a safe and sustainable manner.	22	ECV will develop a programme to promote awareness about the quality of water in its effluent streams and the risks of drinking from or eating fish caught in tailings dams.	Project Start	Mine Closure
		23	Signs in local language/symbols will be posted alerting people to any potential dangers, e.g. drowning, crocodiles.	Project Start	Mine Closure
4. EDUCATION AND TRAINING					
Support to local school.	ECV will support a range of educational facilities as part of the Lumwana Estate(basic, middle and vocational etc.)	24	ECV will provide support to local schools in accordance with specific criteria to ensure sustainability.	Project Start	Mine Closure
5. HEALTH PLAN					
Healthcare for ECV employees.	To ensure employees obtain quality healthcare.	25	ECV will operate the Plant Site Clinic for its employees for the life of the mine.	Project Start	Mine Closure
HIV/AIDS awareness and prevention amongst workers, contractors and the public.	To prevent the further spread of infections and reduce deaths amongst workers and their families.	26	ECV in consultation with Zambian HIV/AIDS organisations and government initiatives will design and implement a HIV/AIDS awareness and prevention campaign.	Project Start	Mine Closure

ASPECT/ISSUE	OBJECTIVE	REF NO.	MANAGEMENT ACTION	TIMING	
				START	END
Malaria Eradication Campaign	To reduce the incidence of malaria amongst workers and their families and the community.	27	ECV will conduct malaria spraying at the mine site and assist Government Health Services to spray local villages.	Project Start	Mine Closure
6. SPORT & RECREATION FACILITIES					
Sustainability of clubs & recreation facilities.	All sports clubs and recreation facilities will be run independently of ECV.	28	ECV will support the construction of facilities as part of the Lumwana Estate	Project Start	Mine Closure
7. COMMUNITY MANAGEMENT					
The relationship between stakeholders and resources.	To assist with the sustainability of community resources.	29	ECV will interact with the local community in a manner that promotes community ownership and self-reliance.	Project Start	Mine Closure
8. PUBLIC CONSULTATION					
Developing relationship between ECV and the public.	To build a relationship with stakeholders and communicate ECV policy on social and environmental management to the public.	30	The EIA public consultation process will continue (regular 6 monthly or annual meetings).	Project Start	Mine Closure
Communication and transparency with stakeholders.	To ensure that all issues are recorded and dealt with and to build trust between ECV and stakeholders.	31	ECV will develop a stakeholder database. The database will contain information on stakeholder identity; issues and concerns raised by stakeholders and how they have been processed by ECV; media articles about ECV; and register of complaints and comment	Project Start	Mine Closure
9. DECOMMISSIONING & CLOSURE PLAN					
Progressive rehabilitation of the mine site.	To restore aspects of the mine site and facilities for community use.	32	ECV will implement a progressive mine reclamation plan to render the mine site usable for other purposes such as recreation at closure.	Project Start	Mine Closure

Appendix H

Letter from Parc Scientific Pty Ltd of South Africa
Regarding Uranium in Copper Tailings

PARC Scientific (Pty) Ltd 96/12589/07

October 14, 2003

Golder Associates Africa (Pty) Ltd

Attention: Nico Bezuidenhout

Lumwana combined uranium / copper tailings

Dear Sir

Concerning your request for information pertaining to the possible impact of ^{226}Ra in the tailings the following:

1. It will be assumed that ^{226}Ra in the ore body, before processing, is in secular radioactive equilibrium with the ^{238}U parent isotope. Radioactive equilibrium occurs in ore bodies as diverse as at Palabora (where copper is mined), the gold bearing reefs of the Witwatersrand and the Free State gold fields, and the mineral sand deposits on the Kwa- Zulu Natal coastline. It seems that as long as the ore body has been undisturbed, radioactive equilibrium will be established.

2. Any increase in the activity concentration of ^{226}Ra in tailings will be due to chemical reactions in the processing operations. This is only likely to occur when the process actually depletes ^{238}U, or concentrates ^{226}Ra. The former may occur e.g. when U is being extracted, whereas the latter is normally only seen in the equipment used with acid or calcining plants. It is clear that the extraction process, and subsequent processing determines the eventual Ra levels in the residues.

3. In this regard, and in the absence of better information, the experience at other mining facilities may be used. At Palabora Mining Co, the ratio of Ra to U in the solid tailings amounts to 0.44. The Ra/U ratio in the tailing liquids ranges from 0.13 to 0.4. At a typical uranium mine in the US Southwest, the Ra/U ration in the solid tailings amounts to 0.07 (NUREG, 1979). No figure for the liquid phase was given. It is clear that some Ra is leached out of the solid material and is redistributed in the liquid phase.

4. The chemical for of Ra in the tailings depends on the chemistry used in the extraction process. If an acidic method is used, Ra will occur in the form of $RaSO_4$. However, the compound only occurs dissolved in liquids, as the mass concentration of Ra is too low too form solid $RaSO_4$. De Jesus, et al, has found that Ra is very immobile in tailings dams, and moves through tailings 1300 – 4500 times more slowly than water.

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5. It should be noted that the uranium concentration referenced by you evolved after considerable "dilution" by copper tailings in a ratio of 384:1. It is not clear if the copper tailings also contained traces of uranium from the ore, or if some uranium is also extracted in the copper extraction process. Furthermore, residues from a uranium plant are mentioned, this will not form part of the intended new operation. If U is not removed in the extraction process of the actual operation, it is expected that the uranium level in the tailings will be closer to that of the ore material. i.e. 0.01 % to 0.007 % . However, even these values will not result in U levels exceeding the effluent limits.

   In terms of the Ra / U *activity* ratios discussed in paragraph 3, and the low U values, it is therefore unlikely that the Ra activity will reach values where the effluent levels will be exceeded.

Note that this evaluation is based on the information available, and experience from operating facilities. Confirmation will be necessary once the operation has commenced.

Please do not hesitate to contact PARC Scientific (Pty) Ltd should there be any further questions.
Sincerely

Dr. Rian Strydom
Director

Appendix I

Lumwana East Road Traffic Survey (June 2001)
Raw Data

Road Traffic Survey, June 2001 - T5 Main Road, Lumwana East

Date	Time	Description						
		Pedestrian	Bicycle	Car	4WD	Mini-Bus	Truck	Coach
18-Jun-01	06.00-07.00	70	6	0	0	1	0	0
18-Jun-01	07.00-08.00	58	13	0	1	0	0	0
18-Jun-01	08-00-09.00	43	4	0	4	0	0	0
18-Jun-01	09.00-10.00	16	8	0	2	0	0	0
18-Jun-01	10.00-11.00	19	20	0	1	1	0	0
18-Jun-01	11.00-12.00	10	12	0	0	0	0	0
18-Jun-01	12.00-13.00	100	10	0	1	0	1	0
18-Jun-01	13.00-14.00	66	14	0	4	0	0	1
18-Jun-01	14.00-15.00	11	8	0	3	0	0	1
18-Jun-01	15.00-16.00	28	7	1	3	0	0	0
18-Jun-01	16.00-17.00	47	12	0	1	0	0	0
18-Jun-01	17.00-18.00	71	15	0	4	0	1	0
	Totals:	**539**	**129**	**1**	**24**	**2**	**2**	**2**

Road Traffic Survey, June 2001 - T5 Main Road, Lumwana East

Date	Time	Description						
		Pedestrian	Bicycle	Car	4WD	Mini-Bus	Truck	Coach
19-Jun-01	06.00-07.00	59	2	0	0	0	0	0
19-Jun-01	07.00-08.00	62	3	0	3	0	0	0
19-Jun-01	08-00-09.00	25	4	0	1	0	0	0
19-Jun-01	09.00-10.00	33	8	0	1	0	0	0
19-Jun-01	10.00-11.00	20	12	0	1	1	1	0
19-Jun-01	11.00-12.00	37	2	0	2	0	0	1
19-Jun-01	12.00-13.00	102	10	0	0	0	0	0
19-Jun-01	13.00-14.00	43	10	0	1	0	0	0
19-Jun-01	14.00-15.00	20	14	0	3	0	0	0
19-Jun-01	15.00-16.00	29	11	0	1	0	0	1
19-Jun-01	16.00-17.00	79	10	0	1	0	1	0
19-Jun-01	17.00-18.00	117	9	0	4	1	1	0
	Totals:	**626**	**95**	**0**	**18**	**2**	**3**	**2**

Road Traffic Survey, June 2001 - T5 Main Road, Lumwana East

Date	Time	Description						
		Pedestrian	Bicycle	Car	4WD	Mini-Bus	Truck	Coach
20-Jun-01	06.00-07.00	46	1	0	1	0	0	0
20-Jun-01	07.00-08.00	21	2	0	1	0	0	0
20-Jun-01	08-00-09.00	18	8	0	3	0	0	0
20-Jun-01	09.00-10.00	33	10	0	1	0	0	0
20-Jun-01	10.00-11.00	54	10	0	3	0	0	0
20-Jun-01	11.00-12.00	19	16	0	0	1	0	0
20-Jun-01	12.00-13.00	51	14	0	1	0	1	1
20-Jun-01	13.00-14.00	25	10	0	1	0	0	0
20-Jun-01	14.00-15.00	13	3	0	3	0	2	0
20-Jun-01	15.00-16.00	26	12	0	4	0	0	1
20-Jun-01	16.00-17.00	66	8	0	3	0	1	0
20-Jun-01	17.00-18.00	52	6	0	2	0	0	0
	Totals:	**424**	**100**	**0**	**23**	**1**	**4**	**2**

Road Traffic Survey, June 2001 - T5 Main Road, Lumwana East

Date	Time	Description						
		Pedestrian	Bicycle	Car	4WD	Mini-Bus	Truck	Coach
22-Jun-01	06.00-07.00	21	2	0	0	0	0	0
22-Jun-01	07.00-08.00	16	9	0	0	0	0	0
22-Jun-01	08-00-09.00	15	11	0	2	0	1	0
22-Jun-01	09.00-10.00	14	10	0	2	0	0	0
22-Jun-01	10.00-11.00	75	16	0	2	0	0	0
22-Jun-01	11.00-12.00	22	10	0	0	1	0	0
22-Jun-01	12.00-13.00	18	6	0	1	0	1	0
22-Jun-01	13.00-14.00	133	13	0	4	0	1	0
22-Jun-01	14.00-15.00	123	5	0	3	1	1	0
22-Jun-01	15.00-16.00	20	15	0	0	0	0	0
22-Jun-01	16.00-17.00	198	11	0	1	0	0	0
22-Jun-01	17.00-18.00	22	8	0	3	0	1	0
	Totals:	**677**	**116**	**0**	**18**	**2**	**5**	**0**

Road Traffic Survey, June 2001 - T5 Main Road, Lumwana East

Date	Time	Description						
		Pedestrian	Bicycle	Car	4WD	Mini-Bus	Truck	Coach
23-Jun-01	06.00-07.00	8	5	0	0	0	0	0
23-Jun-01	07.00-08.00	56	4	0	0	0	0	0
23-Jun-01	08-00-09.00	32	5	0	3	0	0	0
23-Jun-01	09.00-10.00	20	8	0	1	0	1	0
23-Jun-01	10.00-11.00	26	12	0	2	0	0	0
23-Jun-01	11.00-12.00	14	6	0	2	0	1	0
23-Jun-01	12.00-13.00	78	8	0	1	0	0	0
23-Jun-01	13.00-14.00	63	8	0	3	0	0	0
23-Jun-01	14.00-15.00	21	4	0	2	1	1	0
23-Jun-01	15.00-16.00	31	17	0	0	0	0	2
23-Jun-01	16.00-17.00	93	10	0	0	0	1	0
23-Jun-01	17.00-18.00	64	6	0	5	0	0	0
	Totals:	**506**	**93**	**0**	**19**	**1**	**4**	**2**

Road Traffic Survey, June 2001 - T5 Main Road, Lumwana East

Date	Time	Description						
		Pedestrian	Bicycle	Car	4WD	Mini-Bus	Truck	Coach
24-Jun-01	06.00-07.00	9	1	0	0	0	0	0
24-Jun-01	07.00-08.00	6	0	0	2	0	1	0
24-Jun-01	08-00-09.00	33	10	0	2	0	0	0
24-Jun-01	09.00-10.00	25	13	0	3	0	0	0
24-Jun-01	10.00-11.00	14	5	0	2	0	1	0
24-Jun-01	11.00-12.00	21	3	0	4	1	2	2
24-Jun-01	12.00-13.00	15	5	0	1	0	0	0
24-Jun-01	13.00-14.00	13	6	0	0	0	0	0
24-Jun-01	14.00-15.00	26	11	0	2	1	0	0
24-Jun-01	15.00-16.00	18	8	0	2	0	1	0
24-Jun-01	16.00-17.00	43	18	0	1	0	0	0
24-Jun-01	17.00-18.00	32	11	0	4	0	1	0
	Totals:	**255**	**91**	**0**	**23**	**2**	**6**	**2**

Appendix J

Baseline Surface Water, Groundwater, Stream Sediment and Soils Sampling, Sample Storage and Transportation Protocol

Surface water and groundwater sampling, and water sample storage and transportation protocol

New 500ml plastic, lock-cap fitting bottles were used for the storage of all water samples. Sample bottles were used once only to avoid cross contamination. All sample bottles were filled to the top leaving no air space.

Two x 500ml water samples were taken for physical, chemical, bacteriological and total metal analysis. These samples were immediately placed in a cool box packed with ice and maintained at a temperature of between 2 and 6 °C.

Water samples for dissolved metal analysis were filtered directly from the stream or bore hole into a 500ml sample bottle. A peristaltic pump and 45 micron sealed in-line geo-filter was used for this purpose. The first 50ml of sample water was discarded. Each 500ml filtered sample was preserved with 20 drops of Nitric Acid (HNO_3). Thus sample pH was reduced to <2 to prevent the precipitation of metals contained in solution. Filtered samples were also immediately placed in a cool box. The rubber tubing used with the pump was decontaminated after filtering by pumping distilled water through the tube in both directions.

Sampling bottles were clearly labelled using indelible ink. The labelling format was LUM/SW/01-NF or F or LUM/GW/01-NF or F and date. LUM identifies the project, SW indicates sample type (Surface water), GW indicates Groundwater and 01 denotes location. F denotes a filtered sample and NF denotes a non-filtered sample.

Water samples are stored in the field in a cool box filled with ice and later transferred to a refrigerator awaiting transport to the laboratory for analysis. The temperature in the refrigerator is monitored by thermometer, and maintained at 3°C. Samples are delivered to the laboratory in a cool box with ice. The receiving chemist signs the sample chain of custody form.

The quality assurance / quality control (QA/QC) procedure is to carry out duplicate analyses on 10 % of the surface water and groundwater samples and to carry out additional checks using standard reference materials and spiked samples.

Stream sediment sampling, and sediment sample storage and transportation protocol

Sediment sampling is done in the middle of small streams or 2 metres from the shoreline in wider streams and rivers. The sampling tool consists of a stainless steel spade. The spade is decontaminated with distilled water and finally stream water before each sediment sample is taken. The sampler equipped with spade wades into the stream taking care to stand downstream of the sampling point to avoid disturbance of the stream sediment. The spade is carefully lowered into the water and pushed in to the sediment to a depth of approximately 150 mm. The spade containing the sample is slowly brought back to the surface and poured into zip-lock bags. The following sediment sample conditions must be met before the sediment sample is accepted:-

- Overlying water is present indicating minimal leakage;
- The overlying water is not excessively turbid indicating minimal sample disturbance;
- The surface of the sediment should appear relatively undisturbed, indicating a lack of channelling or sample wash-out; and
- The desired penetration depth was achieved.

The sample bags are labelled with indelible ink. The labelling format was Lum/SED-01 and date. Lum identifies the project, SED denotes the sample type and 01 the sample location.

Soil samples are stored in the field in a cool box filled with ice and later transferred to a refrigerator awaiting transport to the laboratory for analysis. The temperature in the refrigerator is monitored by thermometer, and maintained at 3°C. Samples are delivered to the laboratory in a cool box with ice. The receiving chemist signs the sample chain of custody form.

The quality assurance / quality control (QA/QC) procedure is to carry out duplicate analyses on 10 % of the sediment samples and to carry out additional checks using standard reference materials and spiked samples.

Soil sampling, and soil sample storage and transportation protocol

Soil pits are formed by hand to a depth of 300mm using a pick and shovel. Care is taken not to disturb the ground surface above the face to be sampled. Spoil is heaped outside the pit on the opposite side to the sampling face. The soil sample is taken from 0 to 150 mm depth. A stainless steel trowel is used to collect soil from a channel in the sampling face. The sampling face is scraped clean before sampling to prevent sample contamination and the trowel is decontaminated using de-ionised water between taking soil samples. The soil is placed directly in a polyethylene bag with zip fastener, sealed and placed in a cool box packed with ice. The freezer bags are labelled using indelible ink. The labelling format was Lum/SO-01 and date. Lum identifies the project, SO denotes the sample type and 01 the sample location.

All soil samples are transferred directly from the cool box to a refrigerator awaiting transport to the laboratory for analysis. The temperature in the refrigerator is monitored by thermometer, and maintained at 3°C. Samples are delivered to the laboratory in a cool box with ice. The receiving chemist signs the sample chain of custody form.

The quality assurance / quality control (QA/QC) procedure is to carry out duplicate analyses on 10 % of the soil samples and to carry out additional checks using standard reference materials and spiked samples.

Appendix K

Baseline Surface Water and Groundwater Analyses and Field Water Quality Measurements

Surface Water Quality - Physical, Chemical & Bacteriological Analysis

Sampling Point	Sample No.	Sampling Date	Physical, Chemical & Bacteriological Parameters													
			pH	Cond. μS/cm	TDS mg/l	TSS mg/l	SO_4^{2-} Mg/l	F^- mg/l	Cl^- mg/l	NO_3 mg/l	PO_4^{3-} mg/l	CN^- mg/l	Ca mg/l	Colour Hazen (units)	Total Coliform (100 ml)	Faecal Coliform (100 ml)
SW-01	SW/Lum/1a-NF	13.Nov.01	6.9	130	70	10	15	0.2	13	1.8	0.5	<0.1	<0.1	<5	3,200	464
SW-01	SW/Lum/1b-NF	19.Dec.01	6.7	43	25	20	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1c-NF	16.Jan.02	5.3	60	26	11	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1d-NF	19.Feb.02	6.9	33	30	10	5	0.3	1	2	0.3	<0.1	2.0	<5	50	22
SW-01	SW/Lum/1e-NF	19.Mar.02	7.4	38	30	10	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1f-NF	18.Apr.02	6.3	63	40	15	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1g-NF	21.May.02	7.2	33	20	15	20	<0.1	3	<0.1	<0.1	<0.1	4	<5	22	2
SW-01	SW/Lum/1h-NF	18.June.02	7.6	36	30	25	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1i-NF	18.July.02	7.7	44	10	20	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1j-NF	22.Aug.02	7.6	58	50	10	15	<0.1	9	<0.1	1	<0.1	3	<5	Nil	Nil
SW-01	SW/Lum/1k-NF	19.Sep.02	7.4	75	60	<5	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1l-NF	17.Oct.02	7.2	99	76	<5	-	-	-	-	-	-	-	-	-	-

Surface Water Quality - Total Metal Analysis

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Al mg/l	T.As mg/l	T.B Mg/l	T.Ba mg/l	T.Be mg/l	T.Cd mg/l	T.Co mg/l	T.Cr mg/l	T.Cu mg/l	T.Fe mg/l
SW-01	SW/Lum/1a-NF	13.Nov.01	0.5	<0.01	<5	0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.6
SW-01	SW/Lum/1b-NF	19.Dec.01	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-01	SW/Lum/1c-NF	16.Jan.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-01	SW/Lum/1d-NF	19.Feb.02	0.8	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.6
SW-01	SW/Lum/1e-NF	19.Mar.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-01	SW/Lum/1f-NF	18.Apr.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-01	SW/Lum/1g-NF	21.May.02	0.1	<0.01		<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.4
SW-01	SW/Lum/1h-NF	18.June.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-01	SW/Lum/1i-NF	18.July.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-01	SW/Lum/1j-NF	22.Aug.02	0.2	<0.01	0.1	0.4	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-01	SW/Lum/1k-NF	19.Sep.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	0.1	-
SW-01	SW/Lum/1l-NF	17.Oct.02	-	<0.01	-	<0.1	-	<0.01	0.8	-	<0.1	-

NF denotes non-filtered water sample

Surface Water Quality - Total Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Hg mg/l	T.Mg mg/l	T.Mn mg/l	T.Mo mg/l	T.Ni mg/l	T.Pb mg/l	T.Se mg/l	T.V mg/l	T.Zn mg/l	T.U mg/l
SW-01	SW/Lum/1a-NF	13.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	0.34	<0.01	<0.1	<0.1	0.4
SW-01	SW/Lum/1b-NF	19.Dec.01	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-01	SW/Lum/1c-NF	16.Jan.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-01	SW/Lum/1d-NF	19.Feb.02	<0.001	2	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-01	SW/Lum/1e-NF	19.Mar.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-01	SW/Lum/1f-NF	18.Apr.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-01	SW/Lum/1g-NF	21.May.02	<0.001	0.4	<0.1	0.2	<0.1	<0.01	0.02	<0.1	<0.1	0.1
SW-01	SW/Lum/1h-NF	18.June.02	-	-	-	-	-	0.05	-	-	-	0.4
SW-01	SW/Lum/1i-NF	18.July.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-01	SW/Lum/1j-NF	22.Aug.02	<0.001	1	<0.1	<0.1	<0.1	0.1	<0.01	<0.1	<0.1	<0.1
SW-01	SW/Lum/1k-NF	19.Sep.02	-	-	-	-	-	0.2	-	-	-	<0.1
SW-01	SW/Lum/1l-NF	17.Oct.02	-	-	-	-	-	0.1	-	-	-	

NF denotes non-filtered water sample

Surface Water Quality - Dissolved Metal Analysis

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Al mg/l	D.As mg/l	D.B Mg/l	D.Ba mg/l	D.Be mg/l	D.Cd mg/l	D.Co mg/l	D.Cr mg/l	D.Cu mg/l	D.Fe mg/l
SW-01	SW/Lum/1a-F	13.Nov.01	0.1	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.1
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1d-F	19.Feb.02	0.5	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.6
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1g-F	21.May.02	<0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.1
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1j-F	22.Aug.02	<0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Dissolved Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Hg mg/l	D.Mg mg/l	D.Mn mg/l	D.Mo mg/l	D.Ni mg/l	D.Pb mg/l	D.Se mg/l	D.V mg/l	D.Zn mg/l	D.U mg/l
SW-01	SW/Lum/1a-F	13.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	0.03	<0.01	<0.1	<0.1	<0.1
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1d-F	19.Feb.02	<0.001	2	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1g-F	21.May.02	<0.001	0.4	<0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	SW/Lum/1j-F	22.Aug.02	<0.001	1	<0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1
SW-01	-	-	-	-	-	-	-	-	-	-	-	-
SW-01	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Physical, Chemical & Bacteriological Analysis

Sampling Point	Sample No.	Sampling Date	Physical, Chemical & Bacteriological Parameters													
			pH	Cond. μS/cm	TDS mg/l	TSS mg/l	SO_4^{2-} mg/l	F^- mg/l	Cl^- mg/l	NO_3 mg/l	PO_4^{3-} mg/l	CN^- mg/l	Ca mg/l	Colour Hazen (units)	Total Coliform (100 ml)	Faecal Coliform (100 ml)
SW-02	SW/Lum/2a-NF	13.Nov.01	7.1	100	45	10	<5	0.2	8	0.6	0.6	<0.1	<0.1	<5	1,160	208
SW-02	SW/Lum/2b-NF	19.Dec.01	6.7	44	29	14	-	-	-	-	-	-	-	-	-	-
SW-02	SW/Lum/2c-NF	16.Jan.02	6.7	51	32	18	-	-	-	-	-	-	-	-	-	-
SW-02	SW/Lum/2d-NF	19.Feb.02	6.6	34	20	15	5	0.2	2	1	0.6	<0.1	1.0	<5	640	82
SW-02	SW/Lum/2e-NF	19.Mar.02	7.4	40	30	10	-	-	-	-	-	-	-	-	-	-
SW-02	SW/Lum/2f-NF	18.Apr.02	6.9	34	25	10	-	-	-	-	-	-	-	-	-	-
SW-02	SW/Lum/2g-NF	21.May.02	7.1	31	20	15	20	<0.1	3	<0.1	0.5	<0.1	6	<0.5	86	64
SW-02	SW/Lum/2h-NF	18.June.02	7.5	30	20	20	-	-	-	-	-	-	-	-	-	-
SW-02	SW/Lum/2i-NF	18.July.02	7.2	47	20	10	-	-	-	-	-	-	-	-	-	-
SW-02	SW/Lum/2j-NF	22.Aug.02	7.2	68	50	10	25	<0.1	10	<0.1	2	<0.1	4	<5	Nil	Nil
SW-02	SW/Lum/2k-NF	19.Sep.02	6.8	81	40	5	-	-	-	-	-	-	-	-	-	-
SW-02	SW/Lum/2l-NF	17.Oct.02	6.9	168	60	<5	-	-	-	-	-	-	-	-	-	-

Surface Water Quality - Total Metal Analysis

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Al mg/l	T.As Mg/l	T.B mg/l	T.Ba mg/l	T.Be mg/l	T.Cd mg/l	T.Co mg/l	T.Cr mg/l	T.Cu mg/l	T.Fe mg/l
SW-02	SW/Lum/2a-NF	13.Nov.01	0.2	<0.01	<5	0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.7
SW-02	SW.Lum/2b-NF	19.Dec.01	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-02	SW.Lum/2c-NF	16.Jan.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-02	SW.Lum/2d-NF	19.Feb.02	0.3	<0.01	<5	0.2	<0.1	<0.01	<0.1	<0.1	<0.1	0.7
SW-02	SW/Lum/2e-NF	19.Mar.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-02	SW/Lum/2f-NF	18.Apr.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-02	SW/Lum/2g-NF	21.May.02	0.2	0.01	<5	0.6	0.2	<0.01	0.1	<0.1	<0.1	0.4
SW-02	SW/Lum/2h-NF	18.June.02	-	<0.01	-	0.6	-	<0.01	<0.1	-	<0.1	-
SW-02	SW/Lum/2i-NF	18.July.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-02	SW/Lum/2j-NF	22.Aug.02	0.2	<0.01	<0.1	0.2	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-02	SW/Lum/2k-NF	19.Sep.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	0.1	-
SW-02	SW/Lum/2l-NF	17.Oct.02	-		-	<0.1	-	<0.01	0.9	-	<0.1	-

NF denotes non-filtered water sample

Surface Water Quality - Total Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Hg mg/l	T.Mg mg/l	T.Mn mg/l	T.Mo mg/l	T.Ni mg/l	T.Pb mg/l	T.Se mg/l	T.V mg/l	T.Zn mg/l	T.U mg/l
SW-02	SW/Lum/2a-NF	13.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	0.02	<0.01	<0.1	<0.1	0.2
SW-02	SW.Lum/2b-NF	19.Dec.01	-	-	-	-	-	0.02	-	-	-	<0.1
SW-02	SW.Lum/2c-NF	16.Jan.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-02	SW.Lum/2d-NF	19.Feb.02	<0.001	2	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-02	SW/Lum/2e-NF	19.Mar.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-02	SW/Lum/2f-NF	18.Apr.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-02	SW/Lum/2g-NF	21.May.02	<0.001	1	<0.1	<0.1	<0.1	0.01	0.02	<0.1	<0.1	0.2
SW-02	SW/Lum/2h-NF	18.June.02	-	-	-	-	-	0.01	-	-	-	0.4
SW-02	SW/Lum/2i-NF	18.July.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-02	SW/Lum/2j-NF	22.Aug.02	<0.001	1	<0.1	<0.1	<0.1	0.1	<0.01	<0.1	<0.1	<0.1
SW-02	SW/Lum/2k-NF	19.Sep.02	-	-	-	-	-	0.2	-	-	-	<0.1
SW-02	SW/Lum/2l-NF	17.Oct.02	-	-	-	-	-	0.3	-	-	-	

NF denotes non-filtered water sample

Surface Water Quality - Dissolved Metal Analysis

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Al mg/l	D.As mg/l	D.B mg/l	D.Ba mg/l	D.Be mg/l	D.Cd mg/l	D.Co mg/l	D.Cr mg/l	D.Cu mg/l	D.Fe mg/l
SW-02	SW/Lum/2a-F	13.Nov.01	<0.1	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.3
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	SW/Lum/2d-F	19.Feb.02	0.3	<0.01	<5	0.2	<0.1	<0.01	<0.1	<0.1	<0.1	0.7
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	SW/Lum/2g-F	21.May.02	<0.1	<0.01	<5	<0.1	0.2	<0.01	<0.1	<0.1	<0.1	0.1
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	SW/Lum/2j-F	22.Aug.02	<0.1	<0.01	<0.1	<0.1	<0.1	4	<0.1	<0.1	<0.1	<0.1
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Dissolved Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Hg mg/l	D.Mg mg/l	D.Mn mg/l	D.Mo mg/l	D.Ni mg/l	D.Pb mg/l	D.Se mg/l	D.V mg/l	D.Zn mg/l	D.U mg/l
SW-02	SW/Lum/2a-F	13.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	0.02	<0.01	<0.1	<0.1	<0.1
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	SW.Lum/2d-F	19.Feb.02	<0.001	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	SW/Lum/2g-F	21.May.02	<0.001	1.0	<0.1	<0.1	<0.1	0.1	<0.01	<0.1	<0.1	0.2
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	SW/Lum/2j-F	22.Aug.02	<0.001	1	<0.1	<0.1	<0.1	0.1	<0.01	<0.1	<0.1	<0.1
SW-02	-	-	-	-	-	-	-	-	-	-	-	-
SW-02	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Physical, Chemical & Bacteriological Analysis

Sampling Point	Sample No.	Sampling Date	Physical, Chemical & Bacteriological Parameters													
			pH	Cond. μS/cm	TDS mg/l	TSS mg/l	SO_4^{2-} mg/l	F^- mg/l	Cl^- mg/l	NO_3 mg/l	PO_4^{3-} mg/l	CN^- mg/l	Ca mg/l	Colour Hazen (units)	Total Coliform (100 ml)	Faecal Coliform (100 ml)
SW-03	SW/Lum/3a-NF	13.Nov.01	6.9	11	20	5	<5	0.2	6	0.6	1.2	<0.1	<0.1	<5	930	360
SW-03	SW/Lum/3b-NF	19.Dec.01	6.7	59	33	13	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3c-NF	17.Jan.02	6.6	54	41	16	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3d-NF	19.Feb.02	6.6	42	20	25	5	0.2	<0.1	1	<0.1	<0.1	2.0	<5	Nil	Nil
SW-03	SW/Lum/3e-NF	19.Mar.02	7.3	25	10	10	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3f-NF	18.Apr.02	6.5	40	30	10	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3g-NF	21.May.02	7.1	43	35	20	5	<0.1	3	<0.1	4	<0.1	3.0	<5	Nil	Nil
SW-03	SW/Lum/3h-NF	18.June.02	7.3	41	40	25	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3i-NF	18.July.02	7.4	71	20	20	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3j-NF	22.Aug.02	7.6	112	70	10	25	<0.1	6	<0.1	1	<0.1	6	<5	Nil	Nil
SW-03	SW/Lum/3k-NF	19.Sep.02	7.4	132	85	10	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3l-NF	17.Oct.02	7.2	179	95	<5	-	-	-	-	-	-	-	-	-	-

Surface Water Quality - Total Metal Analysis

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Al mg/l	T.As mg/l	T.B mg/l	T.Ba mg/l	T.Be Mg/l	T.Cd mg/l	T.Co mg/l	T.Cr mg/l	T.Cu mg/l	T.Fe mg/l
SW-03	SW/Lum/3a-NF	13.Nov.01	0.3	<0.01	<5	0.2	<0.1	<0.01	<0.1	<0.1	<0.1	0.4
SW-03	SW/Lum/3b-NF	19.Dec.01	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-03	SW/Lum/3c-NF	17.Jan.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-03	SW/Lum/3d-NF	19.Feb.02	0.1	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.5
SW-03	SW/Lum/3e-NF	19.Mar.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-03	SW/Lum/3f-NF	18.Apr.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-03	SW/Lum/3g-NF	21.May.02	0.2	<0.01	0.1	<0.1	0.2	<0.01	<0.1	<0.1	<0.1	0.5
SW-03	SW/Lum/3h-NF	18.June.02	-	<0.01	-	0.1	-	<0.01	0.1	-	<0.1	-
SW-03	SW/Lum/3i-NF	18.July.02	-	0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-03	SW/Lum/3j-NF	22.Aug.02	0.7	<0.01	0.1	0.3	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-03	SW/Lum/3k-NF	19.Sep.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-03	SW/Lum/3l-NF	17.Oct.02	-	<0.01	-	<0.1	-	<0.01	0.8	-	<0.1	-

NF denotes non-filtered water sample

Surface Water Quality - Total Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Hg mg/l	T.Mg mg/l	T.Mn mg/l	T.Mo mg/l	T.Ni mg/l	T.Pb mg/l	T.Se mg/l	T.V mg/l	T.Zn mg/l	T.U mg/l
SW-03	SW/Lum/3a-NF	13.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	0.04	<0.01	<0.1	<0.1	0.4
SW-03	SW/Lum/3b-NF	19.Dec.01	-	-	-	-	-	0.03	-	-	-	<0.1
SW-03	SW/Lum/3c-NF	17.Jan.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-03	SW/Lum/3d-NF	19.Feb.02	<0.001	3	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-03	SW/Lum/3e-NF	19.Mar.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-03	SW/Lum/3f-NF	18.Apr.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-03	SW/Lum/3g-NF	21.May.02	<0.001	1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	0.1
SW-03	SW/Lum/3h-NF	18.June.02	-	-	-	-	-	0.05	-	-	-	<0.1
SW-03	SW/Lum/3i-NF	18.July.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-03	SW/Lum/3j-NF	22.Aug.02	<0.001	3	<0.1	<0.1	<0.1	0.1	<0.01	<0.1	<0.1	<0.1
SW-03	SW/Lum/3k-NF	19.Sep.02	-	-	-	-	-	0.2	-	-	-	<0.1
SW-03	SW/Lum/3l-NF	17.Oct.02	-	-	-	-	-	0.1	-	-	-	

NF denotes non-filtered water sample

Surface Water Quality - Dissolved Metal Analysis

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Al mg/l	D.As mg/l	D.B mg/l	D.Ba mg/l	D.Be Mg/l	D.Cd mg/l	D.Co mg/l	D.Cr mg/l	D.Cu mg/l	D.Fe mg/l
SW-03	SW/Lum/3a-F	13.Nov.01	0.1	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.4
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3d-F	19.Feb.02	0.1	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.3
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3g-F	21.May.02	<0.1	<0.01	<5	<0.1	0.1	<0.01	<0.1	<0.1	<0.1	0.1
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3j-f	22.Aug.02	0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Dissolved Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Hg mg/l	D.Mg mg/l	D.Mn mg/l	D.Mo mg/l	D.Ni mg/l	D.Pb mg/l	D.Se mg/l	D.V mg/l	D.Zn mg/l	D.U mg/l
SW-03	SW/Lum/3a-F	13.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3d-F	19.Feb.02	<0.001	2	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3g-F	21.May.02	<0.001	1	<0.1	<0.1	<0.1	0.1	<0.01	<0.1	<0.1	0.1
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	SW/Lum/3j-f	22.Aug.02	<0.001	3	<0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1
SW-03	-	-	-	-	-	-	-	-	-	-	-	-
SW-03	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Physical, Chemical & Bacteriological Analysis

Sampling Point	Sample No.	Sampling Date	Physical, Chemical & Bacteriological Parameters													
			pH	Cond. μS/cm	TDS mg/l	TSS mg/l	SO_4^{2-} mg/l	F^- mg/l	Cl^- mg/l	NO_3 mg/l	PO_4^{3-} mg/l	CN^- mg/l	Ca mg/l	Colour Hazen (units)	Total Coliform (100 ml)	Faecal Coliform (100 ml)
SW-04	SW/Lum/4a-NF	27.Nov.01	7.2	100	75	5	35	0.2	1.0	0.2	5	<0.1	7	<5	600	128
SW-04	SW/Lum/4b-NF	19.Dec.01	6.8	84	53	12	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4c-NF	17.Jan.02	6.7	61	48	13	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4d-NF	19.Feb.02	6.3	39	25	25	10	0.2	1	1	<0.1	<0.1	2	<5	360	24
SW-04	SW/Lum/4e-NF	19.Mar.02	7.1	24	15	10	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4f-NF	18.Apr.02	6.5	49	20	10	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4g-NF	21.May.02	6.8	56	45	20	25	<0.1	5	<0.1	4	<0.1	2	<5	84	2
SW-04	SW/Lum/4h-NF	18.June.02	6.8	49	40	25	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4i-NF	18.July.02	6.8	83	30	10	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4j-NF	22.Aug.02	7.3	93	90	10	25	<0.1	2	<0.1	<0.1	<0.1	6	<5	Nil	Nil
SW-04	SW/Lum/4k-NF	19.Sep.02	7.0	127	85	10	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4l-NF	17.Oct.02	6.7	126	85	<5	-	-	-	-	-	-	-	-	-	-

Surface Water Quality - Total Metal Analysis

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Al mg/l	T.As mg/l	T.B mg/l	T.Ba mg/l	T.Be mg/l	T.Cd mg/l	T.Co mg/l	T.Cr mg/l	T.Cu mg/l	T.Fe mg/l
SW-04	SW/Lum/4a-NF	27.Nov.01	0.2	<0.01	8	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-04	SW/Lum/4b-NF	19.Dec.01	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-04	SW/Lum/4c-NF	17.Jan.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-04	SW/Lum/4d-NF	19.Feb.02	0.2	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.3
SW-04	SW/Lum/4e-NF	19.Mar.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-04	SW/Lum/4f-NF	18.Apr.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-04	SW/Lum/4g-NF	21.May.02	0.6	0.01	0.1	<0.1	0.3	<0.01	<0.1	<0.1	<0.1	0.4
SW-04	SW/Lum/4h-NF	18.June.02	-	<0.01	-	0.1	-	<0.01	<0.1	-	<0.1	-
SW-04	SW/Lum/4i-NF	18.July.02	-	<0.01	-	0.1	-	<0.01	<0.1	-	0.1	-
SW-04	SW/Lum/4j-NF	22.Aug.02	0.2	<0.01	<0.1	0.9	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-04	SW/Lum/4k-NF	19.Sep.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	0.3	-
SW-04	SW/Lum/4l-NF	17.Oct.02	-		-		-	<0.01	1	-	<0.1	-

NF denotes non-filtered water sample

Surface Water Quality - Total Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Hg mg/l	T.Mg mg/l	T.Mn mg/l	T.Mo mg/l	T.Ni mg/l	T.Pb mg/l	T.Se mg/l	T.V mg/l	T.Zn mg/l	T.U mg/l
SW-04	SW/Lum/4a-NF	27.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	0.04	<0.01	<0.1	<0.1	0.5
SW-04	SW/Lum/4b-NF	19.Dec.01	-	-	-	-	-	0.01	-	-	-	<0.1
SW-04	SW/Lum/4c-NF	17.Jan.02	-	-	-	-	-	0.01	-	-	-	<0.1
SW-04	SW/Lum/4d-NF	19.Feb.02	<0.001	2	<0.1	<0.1	<0.1	0.02	<0.1	<0.1	<0.1	<0.1
SW-04	SW/Lum/4e-NF	19.Mar.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-04	SW/Lum/4f-NF	18.Apr.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-04	SW/Lum/4g-NF	21.May.02	<0.001	0.1	<0.1	<0.1	<0.1	<0.01	0.02	0.1	<0.1	0.3
SW-04	SW/Lum/4h-NF	18.June.02	-	-	-	-	-	<0.01	-	-	-	0.3
SW-04	SW/Lum/4i-NF	18.July.02	-	-	-	-	-	<0.01	-	-	-	0.5
SW-04	SW/Lum/4j-NF	22.Aug.02	<0.001	0.6	<0.1	<0.1	<0.1	0.1	<0.01	0.1	<0.1	<0.1
SW-04	SW/Lum/4k-NF	19.Sep.02	-	-	-	-	-	0.2	-	-	-	<0.1
SW-04	SW/Lum/4l-NF	17.Oct.02	-	-	-	-	-	0.1	-	-	-	

NF denotes non-filtered water sample

Surface Water Quality - Dissolved Metal Analysis

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Al mg/l	D.As mg/l	D.B mg/l	D.Ba mg/l	D.Be mg/l	D.Cd mg/l	D.Co mg/l	D.Cr mg/l	D.Cu mg/l	D.Fe mg/l
W-04	SW/Lum/4a-F	27.Nov.01	<0.1	<0.01	8	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4d-F	19.Feb.02	0.2	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.3
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4g-F	21.May.02	<0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.1
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4j-F	22.Aug.02	<0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Dissolved Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Hg mg/l	D.Mg mg/l	D.Mn mg/l	D.Mo mg/l	D.Ni mg/l	D.Pb mg/l	D.Se mg/l	D.V mg/l	D.Zn mg/l	D.U mg/l
SW-04	SW/Lum/4a-F	27.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	0.04	<0.01	<0.1	<0.1	0.3
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4d-F	19.Feb.02	<0.001	2	<0.1	<0.1	<0.1	0.02	<0.01	<0.1	<0.1	<0.1
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4g-F	21.May.02	<0.001	0.1	<0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	0.1
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	SW/Lum/4j-F	22.Aug.02	<0.001	0.6	<0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1
SW-04	-	-	-	-	-	-	-	-	-	-	-	-
SW-04	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Physical, Chemical & Bacteriological Analysis

Sampling Point	Sample No.	Sampling Date	Physical, Chemical & Bacteriological Parameters													
			pH	Cond. μS/cm	TDS mg/l	TSS mg/l	SO_4^{2-} mg/l	F^- mg/l	Cl^- mg/l	NO_3 mg/l	PO_4^{3-} mg/l	CN^- mg/l	Ca mg/l	Colour Hazen (units)	Total Coliform (100 ml)	Faecal Coliform (100 ml)
SW-05	SW/Lum/5a-NF	14.Nov.01	7.2	101	60	20	<5	0.2	5	0.5	2.0	<0.1	<0.1	<5	1,430	210
SW-05	SW/Lum/5b-NF	19.Dec.01	6.6	27	18	15	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5c-NF	16.Jan.02	6.5	20	18	16	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5d-NF	19.Feb.02	6.4	18	15	35	5	0.2	1	<0.1	<0.1	<0.1	2	<5	180	Nil
SW-05	SW/Lum/5e-NF	19.Mar.02	7.2	44	35	10	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5f-NF	18.Apr.02	6.6	22	20	10	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5g-NF	21.May.02	6.9	20	15	25	15	<0.1	2	<0.1	2	<0.1	4	<5	50	6
SW-05	SW/Lum/5h-NF	18.June.02	7.1	16	10	40	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5i-NF	18.July.02	7.1	26	10	10	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5j-NF	22.Aug.02	7.3	34	30	<5	20	<0.1	2	<0.1	0	<0.1	1	<5	Nil	Nil
SW-05	SW/Lum/5k-NF	19.Sep.02	6.5	36	15	5	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5l-NF	17.Oct.02	6.6	39	25	<5	-	-	-	-	-	-	-	-	-	-

Surface Water Quality - Total Metal Analysis

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Al mg/l	T.As mg/l	T.B mg/l	T.Ba mg/l	T.Be mg/l	T.Cd mg/l	T.Co mg/l	T.Cr mg/l	T.Cu mg/l	T.Fe mg/l
SW-05	SW/Lum/5a-NF	14.Nov.01	0.8	<0.01	<5	0.2	<0.1	<0.01	<0.1	<0.1	<0.1	0.9
SW-05	SW/Lum/5b-NF	19.Dec.01	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-05	SW/Lum/5c-NF	16.Jan.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-05	SW/Lum/5d-NF	19.Feb.02	2	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.4
SW-05	SW/Lum/5e-NF	19.Mar.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-05	SW/Lum/5f-NF	18.Apr.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-05	SW/Lum/5g-NF	21.May.02	0.1	<0.01	<0.1	<0.1	0.3	<0.01	<0.1	<0.1	<0.1	0.4
SW-05	SW/Lum/5h-NF	18.June.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-05	SW/Lum/5i-NF	18.July.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-05	SW/Lum/5j-NF	22.Aug.02	0.3	<0.01	0.1	0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-05	SW/Lum/5k-NF	19.Sep.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1<0	-
SW-05	SW/Lum/5l-NF	17.Oct.02	-	<0.01	-	<0.1	-	<0.01	0.9	-	0.1	-

NF denotes non-filtered water sample

Surface Water Quality - Total Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Hg mg/l	T.Mg mg/l	T.Mn mg/l	T.Mo mg/l	T.Ni mg/l	T.Pb mg/l	T.Se mg/l	T.V mg/l	T.Zn mg/l	T.U mg/l
SW-05	SW/Lum/5a-NF	14.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	0.04	<0.01	<0.1	<0.1	0.6
SW-05	SW/Lum/5b-NF	19.Dec.01	-	-	-	-	-	0.01	-	-	-	<0.1
SW-05	SW/Lum/5c-NF	16.Jan.02	-	-	-	-	-	<0.01	-	-	-	0.3
SW-05	SW/Lum/5d-NF	19.Feb.02	<0.001	2	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	0.5
SW-05	SW/Lum/5e-NF	19.Mar.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-05	SW/Lum/5f-NF	18.Apr.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-05	SW/Lum/5g-NF	21.May.02	<0.001	0.3	<0.1	<0.1	<0.1	<0.01	0.1	0.1	<0.1	<0.1
SW-05	SW/Lum/5h-NF	18.June.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-05	SW/Lum/5i-NF	18.July.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-05	SW/Lum/5j-NF	22.Aug.02	<0.001	1	<0.1	<0.1	<0.1	<0.1	<0.01	0.1	<0.1	<0.01
SW-05	SW/Lum/5k-NF	19.Sep.02	-	-	-	-	-	0.1	-	-	-	<0.1
SW-05	SW/Lum/5l-NF	17.Oct.02	-	-	-	-	-	<0.1	-	-	-	

NF denotes non-filtered water sample

Surface Water Quality - Dissolved Metal Analysis

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Al mg/l	D.As mg/l	D.B mg/l	D.Ba mg/l	D.Be mg/l	D.Cd mg/l	D.Co mg/l	D.Cr mg/l	D.Cu mg/l	D.Fe mg/l
W-05	SW/Lum/5a-F	14.Nov.01	<0.1	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.1
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5d-F	19.Feb.02	0.3	<0.01	0.2	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.4
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5g-F	21.May.02	<0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5j-F	22.Aug.02	0.2	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Dissolved Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Hg mg/l	D.Mg mg/l	D.Mn mg/l	D.Mo mg/l	D.Ni mg/l	D.Pb mg/l	D.Se mg/l	D.V mg/l	D.Zn mg/l	D.U mg/l
SW-05	SW/Lum/5a-F	14.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5d-F	19.Feb.02	<0.001	2	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	0.5
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5g-F	21.May.02	<0.001	0.3	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	SW/Lum/5j-F	22.Aug.02	<0.001	0.9	<0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1
SW-05	-	-	-	-	-	-	-	-	-	-	-	-
SW-05	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Physical, Chemical & Bacteriological Analysis

Sampling Point	Sample No.	Sampling Date	Physical, Chemical & Bacteriological Parameters													
			pH	Cond. μS/cm	TDS mg/l	TSS mg/l	SO_4^{2-} mg/l	F^- mg/l	Cl^- mg/l	NO_3 mg/l	PO_4^{3-} mg/l	CN^- mg/l	Ca mg/l	Colour Hazen (units)	Total Coliform (100 ml)	Faecal Coliform (100 ml)
SW-06	SW/Lum/6a-NF	14.Nov.01	7.3	60	35	5	<5	0.2	1.0	1.8	5.2	<0.1	<0.1	<5	1,280	162
SW-06	SW/Lum/6b-NF	19.Dec.01	6.7	61	34	14	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6c-NF	16.Jan.02	6.6	48	51	51	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6d-NF	19.Feb.02	6.4	34	25	40	15	0.2	1	2.0	0.5	<0.1	12	<5	180	12
SW-06	SW/Lum/6e-NF	19.Mar.02	7.0	28	20	10	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6f-NF	18.Apr.02	6.6	33	30	10	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6g-NF	21.May.02	6.7	34	25	20	25	<0.1	4	<0.1	2	<0.1	3	<5	126	Nil
SW-06	SW/Lum/6h-NF	18.June.02	6.9	27	20	25	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6i-NF	18.July.02	7.0	56	45	15	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6j-NF	22.Aug.02	7.0	62	50	<5	20	0.9	3	<0.1	2	<0.1	3	<5	5	5
SW-06	SW/Lum/6k-NF	19.Sep.02	6.7	75	55	10	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6l-NF	17.Oct.02	6.2	150	65	15	-	-	-	-	-	-	-	-	-	-

Surface Water Quality - Total Metal Analysis

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Al mg/l	T.As mg/l	T.B mg/l	T.Ba mg/l	T.Be mg/l	T.Cd mg/l	T.Co mg/l	T.Cr mg/l	T.Cu mg/l	T.Fe mg/l
SW-06	SW/Lum/6a-NF	14.Nov.01	0.3	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.6
SW-06	SW/Lum/6b-NF	19.Dec.01	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-06	SW/Lum/6c-NF	16.Jan.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-06	SW/Lum/6d-NF	19.Feb.02	0.3	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.5
SW-06	SW/Lum/6e-NF	19.Mar.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-06	SW/Lum/6f-NF	18.Apr.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-06	SW/Lum/6g-NF	21.May.02	0.2	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.2
SW-06	SW/Lum/6h-NF	18.June.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-06	SW/Lum/6i-NF	18.July.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-06	SW/Lum/6j-NF	22.Aug.02	0.4	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-06	SW/Lum/6k-NF	19.Sep.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	0.1	-
SW-06	SW/Lum/6l-NF	17.Oct.02	-	<0.01	-	<0.1	-	<0.01	0.9	-	<0.1	-

NF denotes non-filtered water sample

Surface Water Quality - Total Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Hg mg/l	T.Mg mg/l	T.Mn mg/l	T.Mo mg/l	T.Ni mg/l	T.Pb mg/l	T.Se mg/l	T.V mg/l	T.Zn mg/l	T.U mg/l
SW-06	SW/Lum/6a-NF	14.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	0.01	<0.01	<0.1	<0.1	0.3
SW-06	SW/Lum/6b-NF	19.Dec.01	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-06	SW/Lum/6c-NF	16.Jan.02	-	-	-	-	-	<0.01	-	-	-	0.1
SW-06	SW/Lum/6d-NF	19.Feb.02	<0.001	2	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	0.1
SW-06	SW/Lum/6e-NF	19.Mar.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-06	SW/Lum/6f-NF	18.Apr.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-06	SW/Lum/6g-NF	21.May.02	<0.001	1	<0.1	<0.1	<0.1	<0.01	<0.04	0.1	<0.1	<0.1
SW-06	SW/Lum/6h-NF	18.June.02	-	-	-	-	-	0.02	-	-	-	0.4
SW-06	SW/Lum/6i-NF	18.July.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-06	SW/Lum/6j-NF	22.Aug.02	<0.001	1	<0.1	<0.1	<0.1	0.1	<0.01	0.1	<0.1	<0.1
SW-06	SW/Lum/6k-NF	19.Sep.02	-	-	-	-	-	<0.1	-	-	-	<0.1
SW-06	SW/Lum/6l-NF	17.Oct.02	-	-	-	-	-	<0.1	-	-	-	

NF denotes non-filtered water sample

Surface Water Quality - Dissolved Metal Analysis

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Al mg/l	D.As mg/l	D.B mg/l	D.Ba mg/l	D.Be mg/l	D.Cd mg/l	D.Co mg/l	D.Cr mg/l	D.Cu mg/l	D.Fe mg/l
W-06	SW/Lum/6a-F	14.Nov.01	<0.1	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.1
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6d-F	19.Feb.02	0.3	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.4
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6g-F	21.May.02	<0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6j-F	22.Aug.02	<0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Dissolved Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Hg mg/l	D.Mg mg/l	D.Mn mg/l	D.Mo mg/l	D.Ni mg/l	D.Pb mg/l	D.Se mg/l	D.V mg/l	D.Zn mg/l	D.U mg/l
SW-06	SW/Lum/6a-F	14.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6d-F	19.Feb.02	<0.001	2	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6g-F	21.May.02	<0.001	1	<0.1	<0.1	<0.1	<0.01	<0.01	0.1	<0.1	<0.1
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	SW/Lum/6j-F	22.Aug.02	<0.001	1	<0.1	<0.1	<0.1	<0.1	<0.01	0.1	<0.1	<0.1
SW-06	-	-	-	-	-	-	-	-	-	-	-	-
SW-06	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Physical, Chemical & Bacteriological Analysis

Sampling Point	Sample No.	Sampling Date	Physical, Chemical & Bacteriological Parameters													
			pH	Cond. μS/cm	TDS mg/l	TSS mg/l	SO_4^{2-} mg/l	F^- mg/l	Cl^- mg/l	NO_3 mg/l	PO_4^{3-} mg/l	CN^- mg/l	Ca mg/l	Colour Hazen (units)	Total Coliform (100 ml)	Faecal Coliform (100 ml)
SW-07	SW/Lum/7a-NF	14.Nov.01	7.0	50	50	5	<5	0.2	1.0	0.2	1.4	<0.1	<0.1	<5	700	74
SW-07	SW/Lum/7b-NF	19.Dec.01	6.9	55	40	14	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7c-NF	16.Jan.02	6.8	40	32	4	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7d-NF	19.Feb.02	6.7	31	20	20	15	0.2	2	<1	0.6	<0.1	2	<5	Nil	Nil
SW-07	SW/Lum/7e-NF	19.Mar.02	7.1	35	25	5	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7f-NF	18.Apr.02	7.0	31	25	10	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7g-NF	21.May.02	7.0	33	25	15	20	<0.1	2	<0.1	3	<0.1	3	<5	32	6
SW-07	SW/Lum/7h-NF	18.June.02	7.0	28	25	20	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7i-NF	18.July.02	7.3	48	25	10	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7j-NF	22.Aug.02	7.4	70	50	<5	15	0.5	2	<0.1	4	<0.1	4	<5	Nil	Nil
SW-07	SW/Lum/7k-NF	19.Sep.02	7.2	94	75	10	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7l-NF	17.Oct.02	6.8	131	86	<5	-	-	-	-	-	-	-	-	-	-

Surface Water Quality - Total Metal Analysis

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Al mg/l	T.As mg/l	T.B mg/l	T.Ba mg/l	T.Be mg/l	T.Cd mg/l	T.Co mg/l	T.Cr mg/l	T.Cu mg/l	T.Fe mg/l
SW-07	SW/Lum/7a-NF	14.Nov.01	0.4	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.3
SW-07	SW/Lum/7b-NF	19.Dec.01	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-07	SW/Lum/7c-NF	16.Jan.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-07	SW/Lum/7d-NF	19.Feb.02	0.3	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.7
SW-07	SW/Lum/7e-NF	19.Mar.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-07	SW/Lum/7f-NF	18.Apr.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-07	SW/Lum/7g-NF	21.May.02	0.1	<0.01	,0.1	<0.1	0.2	<0.01	<0.1	<0.1	<0.1	0.3
SW-07	SW/Lum/7h-NF	18.June.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-07	SW/Lum/7i-NF	18.July.02	-	0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
SW-07	SW/Lum/7j-NF	22.Aug.02	0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-07	SW/Lum/7k-NF	19.Sep.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	0.1	-
SW-07	SW/Lum/7l-NF	17.Oct.02	-	<0.01	-	<0.1	-	<0.01	0.7	-	<0.1	-

F denotes non-filtered water sample

Surface Water Quality - Total Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Hg mg/l	T.Mg mg/l	T.Mn mg/l	T.Mo mg/l	T.Ni mg/l	T.Pb mg/l	T.Se mg/l	T.V mg/l	T.Zn mg/l	T.U mg/l
SW-07	SW/Lum/7a-NF	14.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	0.7
SW-07	SW/Lum/7b-NF	19.Dec.01	-	-	-	-	-	0.01	-	-	-	<0.1
SW-07	SW/Lum/7c-NF	16.Jan.02	-	-	-	-	-	<0.01	-	-	-	0.3
SW-07	SW/Lum/7d-NF	19.Feb.02	<0.001	2	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	0.2
SW-07	SW/Lum/7e-NF	19.Mar.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-07	SW/Lum/7f-NF	18.Apr.02	-	-	-	-	-	<0.01	-	-	-	<0.1
SW-07	SW/Lum/7g-NF	21.May.02	<0.001	1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-07	SW/Lum/7h-NF	18.June.02	-	-	-	-	-	<0.01	-	-	-	0.2
SW-07	SW/Lum/7i-NF	18.July.02	-	-	-	-	-	<0.01	-	-	-	0.1
SW-07	SW/Lum/7j-NF	22.Aug.02	<0.001	2	<0.1	<0.1	<0.1	0.1	<0.01	<0.1	<0.1	<0.1
SW-07	SW/Lum/7k-NF	19.Sep.02	-	-	-	-	-	0.1	-	-	-	<0.1
SW-07	SW/Lum/7l-NF	17.Oct.02	-	-	-	-	-	0.1	-	-	-	

NF denotes non-filtered water sample

Surface Water Quality - Dissolved Metal Analysis

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Al mg/l	D.As mg/l	D.B mg/l	D.Ba mg/l	D.Be mg/l	D.Cd mg/l	D.Co mg/l	D.Cr mg/l	D.Cu mg/l	D.Fe mg/l
W-07	SW/Lum/7a-F	14.Nov.01	<0.1	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.3
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7d-F	19.Feb.02	<0.1	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.4
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7g-F	21.May.02	<0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7j-F	22.Aug.02	<0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Dissolved Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Hg mg/l	D.Mg mg/l	D.Mn mg/l	D.Mo mg/l	D.Ni mg/l	D.Pb mg/l	D.Se mg/l	D.V mg/l	D.Zn mg/l	D.U mg/l
SW-07	SW/Lum/7a-F	14.Nov.01	<0.001	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7d-F	19.Feb.02	<0.001	1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7g-F	21.May.02	<0.001	1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	SW/Lum/7j-F	22.Aug.02	<0.001-	2	<0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1
SW-07	-	-	-	-	-	-	-	-	-	-	-	-
SW-07	-	-		-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Surface Water Quality - Physical, Chemical & Bacteriological Analysis

Sampling Point	Sample No.	Sampling Date	Physical, Chemical & Bacteriological Parameters													
			pH	Cond. μS/cm	TDS mg/l	TSS mg/l	SO_4^{2-} mg/l	F^- mg/l	Cl^- mg/l	NO_3 mg/l	PO_4^{3-} mg/l	CN^- mg/l	Ca mg/l	Colour Hazen (units)	Total Coliform (100 ml)	Faecal Coliform (100 ml)
SW-08	SW/Lum/8a-NF	19.Sep.02	6.8	60	45	20	<5	-	-	-	-	-	-	-	-	-
SW-08	SW/Lum/8b-NF	17.Oct.02	6.5	66	30	<5	<5	-	-	-	-	-	-	-	-	-

NF denotes non-filtered water sample

Surface Water Quality - Total Metal Analysis

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Al mg/l	T.As mg/l	T.B mg/l	T.Ba mg/l	T.Be mg/l	T.Cd mg/l	T.Co mg/l	T.Cr mg/l	T.Cu mg/l	T.Fe mg/l
SW-08	SW/Lum/8a-NF	19.Sep.02	-	<0.01	-	<0.1	-	-	<0.1	-	0.1	1.0
SW-08	SW/Lum/8b-NF	17.Oct.02	-	<0.01	-	<0.1	-	0.02	0.9	-	<0.1	0.8

NF denotes non-filtered water sample

Surface Water Quality - Total Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Hg mg/l	T.Mg mg/l	T.Mn mg/l	T.Mo mg/l	T.Ni mg/l	T.Pb mg/l	T.Se mg/l	T.V mg/l	T.Zn mg/l	T.U mg/l
SW-08	SW/Lum/8a-NF	19.Sep.02	-	-	-	-	-	0.2	-	-	-	<0.1
SW-08	SW/Lum/8b-NF	17.Oct.02	-	-	-	-	-	<0.1	-	-	-	

NF denotes non-filtered water sample

Surface Water Quality - Physical, Chemical & Bacteriological Analysis

Sampling Point	Sample No.	Sampling Date	Physical, Chemical & Bacteriological Parameters													
			pH	Cond. μS/cm	TDS mg/l	TSS mg/l	SO_4^{2-} mg/l	F^- mg/l	Cl^- mg/l	NO_3 mg/l	PO_4^{3-} mg/l	CN^- mg/l	Ca mg/l	Colour Hazen (units)	Total Coliform (100 ml)	Faecal Coliform (100 ml)
SW-09	SW/Lum/9a-NF	19.Sept.02	7.0	949	710	15	430	-	-	-	-	-	-	-	-	-
SW-09	SW/Lum/9b-NF	17.Oct.02	6.6	1022	760	20	465	-	-	-	-	-	-	-	-	-

NF denotes non-filtered water sample

Surface Water Quality - Total Metal Analysis

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Al mg/l	T.As mg/l	T.B mg/l	T.Ba mg/l	T.Be mg/l	T.Cd mg/l	T.Co mg/l	T.Cr mg/l	T.Cu mg/l	T.Fe mg/l
SW-09	SW/Lum/9a-NF	19.Sept.02	-	<0.01	-	-	-	<0.01	<0.1	-	0.3	1.0
SW-09	SW/Lum/9b-NF	17.Oct.02	-	<0.01	-	-	-	0.01	0.9	-	0.1	1.0

NF denotes non-filtered water sample

Surface Water Quality - Total Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Hg mg/l	T.Mg mg/l	T.Mn mg/l	T.Mo mg/l	T.Ni mg/l	T.Pb mg/l	T.Se mg/l	T.V mg/l	T.Zn mg/l	T.U mg/l
SW-09	SW/Lum/9a-NF	19.Sept.02	-	-	-	-	-	0.1	-	-	-	<0.1
SW-09	SW/Lum/9b-NF	17.Oct.02	-	-	-	-	-	<0.1	-	-	-	

NF denotes non-filtered water sample

Groundwater - Physical, Chemical & Bacteriological Analysis (BH MAD-053)

Sampling Point	Sample No.	Sampling Date	Physical, Chemical & Bacteriological Parameters													
			pH	Cond. μS/cm	TDS mg/l	TSS mg/l	SO_4^{2-} mg/l	F^- mg/l	Cl^- mg/l	NO_3 Mg/l	PO_4^{3-} mg/l	CN^- mg/l	Ca mg/l	Colour Hazen (units)	Total Coliform (100 ml)	Faecal Coliform (100 ml)
GW-01	GW/Lum/1a-NF	27.Nov.01	7.4	1700	1420	5	910	0.4	1.0	0.6	5	<0.1	260	<5	Nil	Nil
GW-01	GW/Lum/1b-NF	19.Dec.01	7.3	1667	1453	12	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1c-NF	16.Jan.02	7.3	1560	1359	14	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1d-NF	19.Feb.02	7.1	1617	1450	10	990	0.4	5	<0.1	<0.1	<0.1	5	<5	Nil	Nil
GW-01	GW/Lum/1e-NF	19.Mar.02	7.2	1550	1470	5	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1f-NF	18.Apr.02	7.2	1458	1390	10	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1gNF	21.May.02	7.17	1335	1275	15	850	<0.1	30	<0.1	<0.1	<0.1	3	<5	Nil	Nil
GW-01	GW/Lum/1h-NF	18.June.02	.0	1083	1025	30	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1i-NF	18.July.02	7.2	1778	1345	5	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1j-NF	22.Aug.02	7.7	1834	1440	<5	810	0.7	9	<0.1	1	<0.1	184	<5	Nil	Nil
GW-01	GW/Lum/1k-NF	19.Sep.02	7.3	1687	1360	10	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1l-NF	17.Oct.02	6.9	1695	1400	<5	-	-	-	-	-	-	-	-	-	-

Groundwater - Total Metal Analysis (BH MAD-053)

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Al mg/l	T.As mg/l	T.B mg/l	T.Ba mg/l	T.Be mg/l	T.Cd mg/l	T.Co mg/l	T.Cr mg/l	T.Cu mg/l	T.Fe mg/l
GW-01	GW/Lum/1a-NF	27.Nov.01	<0.1	<0.01	10	<0.1	<0.1	0.01	<0.1	<0.1	<0.1	<0.1
GW-01	GW/Lum/1b-NF	19.Dec.01	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
GW-01	GW/Lum/1c-NF	16.Jan.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
GW-01	GW/Lum/1d-NF	19.Feb.02	0.4	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.5
GW-01	GW/Lum/1e-NF	19.Mar.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
GW-01	GW/Lum/1f-NF	18.Apr.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
GW-01	GW/Lum/1gNF	21.May.02	<0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.5
GW-01	GW/Lum/1h-NF	18.June.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	0.7	-
GW-01	GW/Lum/1i-NF	18.July.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
GW-01	GW/Lum/1j-NF	22.Aug.02	0.2	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
GW-01	GW/Lum/1k-NF	19.Sep.02	-	<0.01	-	<0.1	-	<0.01	<0.1	-	<0.1	-
GW-01	GW/Lum/1l-NF	17.Oct.02	-	<0.01	-	<0.1	-	0.01	0.9	-	<0.1	-

NF denotes non-filtered water sample

Groundwater Quality - Total Metal Analysis (BH MAD-053 cont.)

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Hg mg/l	T.Mg mg/l	T.Mn mg/l	T.Mo mg/l	T.Ni mg/l	T.Pb mg/l	T.Se mg/l	T.V mg/l	T.Zn mg/l	T.U mg/l
GW-01	GW/Lum/1a-NF	27.Nov.01	<0.001	97	<0.1	0.1	<0.1	<0.01	<0.01	<0.1	<0.1	0.4
GW-01	GW/Lum/1b-NF	19.Dec.01	-	-	-	-	-	<0.01	-	-	-	<0.1
GW-01	GW/Lum/1c-NF	16.Jan.02	-	-	-	-	-	<0.01	-	-	-	0.1
GW-01	GW/Lum/1d-NF	19.Feb.02	<0.001	2	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	0.1
GW-01	GW/Lum/1e-NF	19.Mar.02	-	-	-	-	-	<0.01	-	-	-	<0.1
GW-01	GW/Lum/1f-NF	18.Apr.02	-	-	-	-	-	<0.01	-	-	-	<0.1
GW-01	GW/Lum/1gNF	21.May.02	<0.001	46	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	0.1
GW-01	GW/Lum/1h-NF	18.June.02	-	-	-	-	-	0.03	-	-	-	0.4
GW-01	GW/Lum/1i-NF	18.July.02	-	-	-	-	-	<0.01	-	-	-	0.1
GW-01	GW/Lum/1j-NF	22.Aug.02		44	<0.1	<0.1	<0.1	0.1	<0.01		<0.1	<0.1
GW-01	GW/Lum/1k-NF	19.Sep.02	-	-	-	-	-	0.2	-	-	-	<0.1
GW-01	GW/Lum/1l-NF	17.Oct.02	-	-	-	-	-	0.1	-	-	-	

NF denotes non-filtered water sample

Groundwater Quality - Dissolved Metal Analysis (BH MAD-053)

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Al mg/l	D.As mg/l	D.B mg/l	D.Ba mg/l	D.Be mg/l	D.Cd mg/l	D.Co mg/l	D.Cr mg/l	D.Cu mg/l	D.Fe mg/l
GW-01	GW/Lum/1a-F	27.Nov.01	<0.1	<0.01	5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1d-F	19.Feb.02	0.2	<0.01	<5	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.4
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1g-F	21.May.02	<0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	0.4
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1j-F	22.Aug.02	<0.1	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1	<0.1	<0.1
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Groundwater Quality - Dissolved Metal Analysis (BH MAD-053 cont.)

Sampling Point	Sample No.	Sampling Date	Dissolved Metals									
			D.Hg mg/l	D.Mg mg/l	D.Mn mg/l	D.Mo mg/l	D.Ni mg/l	D.Pb mg/l	D.Se mg/l	D.V mg/l	D.Zn mg/l	D.U mg/l
GW-01	GW/Lum1a-F	27.Nov.01	<0.001	79	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	0.3
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1d-F	19.Feb.02	<0.001	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1g-F	21.May.02	<0.001	46	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.1
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	GW/Lum/1j-F	22.Aug.02		32	<0.1	<0.1	<0.1	<0.1	<0.01		<0.1	<0.1
GW-01	-	-	-	-	-	-	-	-	-	-	-	-
GW-01	-	-	-	-	-	-	-	-	-	-	-	-

F denotes filtered water sample

Ground Water Quality - Physical, Chemical & Bacteriological Analysis

Sampling Point	Sample No.	Sampling Date	Physical, Chemical & Bacteriological Parameters													
			pH	Cond. μS/cm	TDS mg/l	TSS mg/l	SO_4^{2-} mg/l	F^- mg/l	Cl^- mg/l	NO_3 mg/l	PO_4^{3-} mg/l	CN^- mg/l	Ca mg/l	Colour Hazen (units)	Total Coliform (100 ml)	Faecal Coliform (100 ml)
GW-02	GW/Lum/02-NF	17.Oct.02	4.5	35	70	15	<5	-	-	-	-	-	-	-	-	-

NF denotes non-filtered water sample

Ground Water Quality - Total Metal Analysis

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Al mg/l	T.As mg/l	T.B mg/l	T.Ba mg/l	T.Be mg/l	T.Cd mg/l	T.Co mg/l	T.Cr mg/l	T.Cu mg/l	T.Fe mg/l
GW-02	GW/Lum/02-NF	17.Oct.02	-	<0.01	-	<0.1	-	0.02	0.7	-	0.1	0.5

NF denotes non-filtered water sample

Ground Water Quality - Total Metal Analysis (cont.)

Sampling Point	Sample No.	Sampling Date	Total Metals									
			T.Hg mg/l	T.Mg mg/l	T.Mn mg/l	T.Mo mg/l	T.Ni mg/l	T.Pb mg/l	T.Se mg/l	T.V mg/l	T.Zn mg/l	T.U mg/l
GW-02	GW/Lum/02-NF	17.Oct.02	-	-	-	-	-	0.1	-	-	-	

NF denotes non-filtered water sample

Surface Water Quality and Stream Flow Rate - Field Measurements (SW-01)

Sampling Point	Date	Parameters						Stream flow rate l/s	Comments
		PH	Cond. (μS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Temp. (°C)	Salinity (%)		
SW-01	13.Nov.01	5.8	90	2	8.8	21.6	0	-	08:30 hrs. Clear water, rocky bed, light showers.
SW-01	19.Dec.01	5.5	21	1	8.3	21.8	0	-	10:16 hrs. Clear water, rocky bed, cloudy and warm.
SW-01	16.Jan.02	5.9	19	0	8.9	20.2	0	-	11:30 hrs. Clear water, cloudy & warm, fast flowing.
SW-01	19.Feb.02	6.2	16	2	8.6	23.1	0	-	14:00 hrs. Clear water, cloudy & hot, turbulent flow.
SW-01	19.Mar.02	6.2	20	0	8.9	22.2	0	-	14:15 hrs. Clear water, light rain, turbulent flow.
SW-01	18.Apr.02	6.0	19	0	8.7	20.5	0	-	13:45 hrs. Clear water, hot & sunny, turbulent flow.
SW-01	21.May.02	6.15	18	0	9.3	16.7	0	-	16:35 hrs. Clear water, warm & sunny, mod flow.
SW-01	18.June.02	.8	20	0	8.3	14.4	0	-	13:55 hrs. Clear water, warm & sunny, mod flow.
SW-01	18.July.02	6.3	24	0	9.9	14.7	0	-	16:46 hrs. Clear water, warm & sunny, mod flow.
SW-01	22. Aug.02	5.5	32	0	7.5	15.9	0	-	09:50 hrs. Clear water, warm & sunny, mod flow.
SW-01	19.Sep.02	7.2	35	3	6.8	18.0	0	-	16:00.hrs. Clear water, warm & sunny, mod flow.
SW-01	17.Oct.02	6.4	54	0	8.65	22.8	0	-	

Surface Water Quality and Stream Flow Rate - Field Measurements (SW-02)

Sampling Point	Date	Parameters						Stream flow rate l/s	Comments
		pH	Cond. (μS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Temp. (°C)	Salinity (%)		
SW-02	13.Nov.01	5.8	60	1	8.9	22.3	0	1,459	10:24 hrs. Clear water, sandy/gravel bed, cloudy.
SW-02	19.Dec.01	6.1	27	5	7.7	22.1	0	1,040	12:15 hrs. Tainted water, sunny and hot.
SW-02	16.Jan.02	5.8	22	0	8.9	20.5	0	1,134	12:30 hrs. Clear water, cloudy & warm, fast flow.
SW-02	19.Feb.02	6.2	18	6	8.3	21.4	0	1,778	07:30 hrs. Tainted water, cloudy & cool, fast flow.
SW-02	19.Mar.02	6.1	22	1	8.8	22.1	0	2,800	13:30 hrs. Brown tint, cloudy & hot, turbulent flow.
SW-02	18.Apr.02	6.5	19	0	8.8	20.4	0	2,920	13:10 hrs. Brown tint, hot and sunny, strong flow.
SW-02	21.May.02	6.2	19	0	9.6	16.1	0	2,293	10:30 hrs. Clear water, warm & sunny, strong flow.
SW-02	18.June.02	5.6	22	0	8.9	14.6	0	2,147	15:10 hrs. Brown tint, warm & sunny, strong flow.
SW-02	18.July.02	6.5	26	0	8.9	13.4	0	914	10:30 hrs. Brown tint, warm & sunny, mod. flow.
SW-02	21.Aug.02	6.0	35	0	7.4	17.3	0	592	17:50 hrs. Burnt dambo, brown tint, moderate flow.
SW-02	18.Sep.02	7.1	38	3	6.95	20.6	0	522	16:05 hrs. Brown tint, warm & sunny, moderate flow.
SW-02	17.Oct.02	6.2	101	0	8.81	20.8	0	137	11:10 hrs. Clear Water, warm & sunny, moderate flow.

Surface Water Quality and Stream Flow Rate - Field Measurements (SW-03)

Sampling Point	Date	Parameters						Stream Flow rate l/s	Comments
		pH	Cond. (μS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Temp. (°C)	Salinity (%)		
SW-03	13.Nov.01	6.0	70	12	7.9	22.0	0	-	12:10 hrs. Tainted brown water, light showers.
SW-03	19.Dec.01	6.4	37	17	6.5	22.4	0	-	15:30 hrs. Brownish water, cloudy and hot.
SW-03	17.Jan.02	6.5	30	26	7.1	20.6	0	11,430	16:00 hrs. Murky brown water, drizzling.
SW-03	19.Feb.02	6.0	23	39	5.1	23.3	0	in flood	16:05 hrs. Murky brown water, clear sky, in flood.
SW-03	19.Mar.02	6.0	25	6	7.4	21.8	0	in flood	16:40 hrs. Brownish water, light rain, swift flowing.
SW-03	18.Apr.02	6.1	27	15	7.8	20.6	0	in flood	15:25 hrs. Green brown tint, hot & sunny, strong flow
SW-03	21.May.02	6.1	31	10	8.0	16.8	0	8,200	18:00 hrs. Brown/green tint, cool, moderate flow.
SW-03	18.June.02	6.0	35	10	7.4	14.7	0	3,150	14:25 hrs. Brown/green tint, warm, strong flow.
SW-03	18.July.02	6.2	42	1	7.8	15.4	0	2,560	15:50 hrs. Brown tint, warm & sunny, strong flow.
SW-03	22.Aug.02	6.6	59	0	6.7	15.3	0	2700	08:30 hrs. Brown/green tint, silty bed, cool clear day.
SW-03	18.Sep.02	6.7	71	2	7.06	20.0	0	1950	17:35 hrs. Brown/green tint, silty bed, mod flow.
SW-03	17.Oct.02	6.8	116	0	8.14	22.6	0	1860	17:30 hrs. Brown/green tint, silty bed, mod flow.

Surface Water Quality and Stream Flow Rate - Field Measurements (SW-04)

Sampling Point	Date	Parameters						Stream flow rate l/s	Comments
		pH	Cond. (μS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Temp. (°C)	Salinity (%)		
SW-04	27.Nov.01	6.2	60	3	6.6	23.1	0	100	12:30 hrs. Clear water, sand/mud bed. Showers.
SW-04	19.Dec.01	6.2	47	5	6.1	22.8	0	53	14:05 hrs. Tainted water, cloudy and hot.
SW-04	17.Jan.02	5.8	37	6	6.9	20.9	0	115	11:00 hrs. Clear water, slightly cloudy & hot.
SW-04	19.Feb.02	6.1	22	5	6.2	21.4	0	394	10:32 hrs. Clear water, cloudy, medium flow.
SW-04	19.Mar.02	5.9	30	5	6.8	21.0	0	320	10:00 hrs. Clear water, warm & sunny, & turbulent.
SW-04	18.Apr.02	6.0	33	5	7.4	19.8	0	154	09:20 hrs. Clear water, sunny & warm, mod flow.
SW-04	21.May.02	6.8	38	0	6.6	16.8	0	152	08:15 hrs. Clear water, warm & sunny, mod flow.
SW-04	18.June.02	5.9	43	5	8.7	15.1	0	73	08:10 hrs. Clear water, sunny & cool, slight flow.
SW-04	18.July.02	6.0	52	0	8.5	15.8	0	66	11:05 hrs. Clear water, sunny & cool, slight flow.
SW-04	21.Aug.02	5.8	61	0	7.7	19.4	0	69	16:45 hrs. Brown/green tint, silty bed. cool clear day.
SW-04	18.Sep.02	6.3	68	3	5.64	20.0	0	66	14:30 hrs. Clear water, sunny & hot, slight flow.
SW-04	17.Oct.02	5.9	85	0	7.02	22.4	0	66	09:30 hrs. Clear water, sunny & hot moderate flow.

Surface Water Quality and Stream Flow Rate - Field Measurements (SW-05)

Sampling Point	Date	Parameters						Stream flow rate l/s	Comments
		pH	Cond. (μS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Temp. (°C)	Salinity (%)		
SW-05	14.Nov.01	6.1	10	1	9.0	21.4	0	393	10:12 hrs. Clear water, sandy bed, sunny and warm.
SW-05	19.Dec.01	5.8	13	3	7.7	20.2	0	423	09:27 hrs. Slightly tainted water, cloudy and warm.
SW-05	16.Jan.02	6.2	10	0	8.5	19.7	0	501	11:00 hrs. Clear water, cloudy and warm.
SW-05	19.Feb.02	5.3	10	4	8.6	21.3	0	886	08.30 hrs. Clear water, cloudy, strong flow.
SW-05	19.Mar.02	5.2	12	5	8.2	21.0	0	820	15:20 hrs. Brownish tint, light rain, warm, mod flow.
SW-05	18 Apr.02	5.6	11	0	8.8	20.1	0	670	14:40 hrs. Clear water, sunny & hot, mod flow.
SW-05	21.May.02	5.7	9	0	9.1	16.4	0	436	17:05 hrs. Brownish tint, sunny & warm, mod flow.
SW-05	18.June.02	4.9	10	0	8.2	11.2	0	388	17:15 hrs. Clear water, sunny & cool, mod flow.
SW-05	18.July.02	5.5	12	0	9.2	14.0	0	264	17:30 hrs. Clear water, sunny & cool, mod flow.
SW-05	22.Aug.02	5.3	14	0	7.8	15.4	0	164	10:35 hrs. Clear water, sunny & cool, mMod flow.
SW-05	18.Sep. 02	6.1	14	3	7.29	19.5	0	106	16:50 hrs. Clear water, sunny & hot, mod flow.
SW-05	17.Oct.02	6.5	21	0	8.94	22.6	0	82	15:10 hrs. Clear water sunny & hot mod flow.

Surface Water Quality and Stream Flow Rate - Field Measurements (SW-06)

Sampling Point	Date	Parameters						Stream flow rate l/s	Comments
		pH	Cond. (μS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Temp. (°C)	Salinity (%)		
SW-06	14.Nov.01	6.0	40	1	7.7	20.2	0	9.6	11:42 hrs. Clear water, sandy/gravel bed, cloudy.
SW-06	19.Dec.01	6.4	33	4	7.3	20.1	0	11.5	08:30 hrs. Tainted brown./green, cloudy and cool.
SW-06	16.Jan.02	5.7	25	5	8.2	19.7	0	14.1	10:30 hrs. Clear water, cloudy and cool.
SW-06	19.Feb.02	6.1	19	5	8.2	21.2	0	14.6	08:01 hrs. Clear water, cloudy, flowing over bridge.
SW-06	19.Mar.02	5.5	17	5	8.4	20.8	0	14.3	14:30 hrs. Clear water, cloudy, flowing over bridge.
SW-06	18.Apr.02	6.0	20	0	8.3	20.1	0	13.5	13.55 hrs. Clear water, sunny & hot, moderate flow.
SW-06	21.May.02	6.0	32	0	8.8	17.9	0	12.0	16:10 hrs. Clear water, cool, flowing over bridge.
SW-06	18.June.02	6.0	24	0	7.9	15.1	0	9.5	13:45 hrs. Clear water, sunny & warm, slight flow.
SW-06	18.July.02	6.6	25	0	8.2	15.8	0	5.0	16:18 hrs. Clear water, sunny & warm, slight flow.
SW-06	22.Aug.02	5.8	33	0	7.4	13.6	0	3.3	10:15 hrs. Clear water, red/brown sediment. slight flow.
SW-06	18. Sep. 02	6.2	39	34	6.29	18.8	0	1.7	16:35 hrs. Red/brown tint, red/brown sediment, low flow.
SW-06	17.Oct.02	6.0	9	-	0.80	18.6	0	1.5	10:25 hrs. Red/brown tint, organic sediment, low flow.

Surface Water Quality and Stream Flow Rate - Field Measurements (SW-07)

Sampling Point	Date	Parameters						Stream flow rate l/s	Comments
		pH	Cond. (μS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Temp. (°C)	Salinity (%)		
SW-07	14.Nov.01	6.3	30	4	8.6	20.3	0	316	13:26 hrs. Tainted water, hot & sunny, slight flow.
SW-07	19.Dec.01	6.2	28	3	7.5	21.2	0	449	11:25 hrs. Tainted water, sunny and hot, slight flow.
SW-07	16.Jan.02	6.4	17	3	8.5	20.6	0	728	17:00 hrs. Tainted brown, cloudy & warm, mod flow.
SW-07	19.Feb.02	5.9	16	4	8.3	21.3	0	959	09:06 hrs. Tainted green/brown, cloudy, fast flowing.
SW-07	19.Mar.02	6.3	20	2	8.6	21.5	0	1,800	09:00 hrs. Clear water, hot & sunny, fast flowing.
SW-07	18.Apr.02	5.9	20	0	8.9	19.7	0	1,590	14:15 hrs. brown tint, sunny & hot, strong flow.
SW-07	21.May.02	5.9	21	0	9.2	16.1	0	1,117	09:15 hrs. Clear water, warm & sunny, moderate flow
SW-07	18.June.02	5.8	21	0	8.5	11.5	0	886	15:56 hrs. Clear water, warm & sunny, moderate flow
SW-07	18.July.02	6.5	27	0	9.0	12.6	0	504	09:30 hrs. Clear water, warm & cool, slight flow.
SW-07	21.Aug.02	6.3	34	0	7.6	17.0	0	336	17:35 hrs. Clear water, warm, slight flow, faecal odour.
SW-07	18.Ssep.02	6.8	48	3	7.0	19.7	0	131	15:30 hrs. Clear water, hot & sunny, slight flow.
SW-07	17.Oct.02	6.4	78	0	8.81	20.7	0	68	12:00 hrs. Clear water, hot & sunny, very low flow

Surface Water Quality and Stream Flow Rate - Field Measurements (SW-08)

Sampling Point	Date	Parameters						Stream flow rate l/s	Comments
		pH	Cond. (μS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Temp. (°C)	Salinity (%)		
SW-08	19.Sep.02	7.0	29	2	6.6	17.6	0	-	09:30 hrs. Clear water, hot & sunny, low flow.
SW-08	17.Oct.02	6.5	42	-	6.37	24.6	0	-	15:55 hrs. Tainted brown, hot & sunny, low flow.

Surface Water Quality and Stream Flow Rate - Field Measurements (SW-09)

Sampling Point	Date	Parameters						Stream flow rate l/s	Comments
		pH	Cond. (μS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Temp. (°C)	Salinity (%)		
SW-09	19.Sep.02	6.3	584	9	5.31	19.5	0.02	-	10:00 hrs. Clear water, hot & sunny, low flow.
SW.09	17.Oct.02	6.3	990	-	7.58	20.4	0.04	-	11:00 hrs. Clear Water. hot & sunny, low flow.

Groundwater Quality - Field Measurements (Drill Hole MAD-53)

Sampling Point	Date	Parameters						Comments
		pH	Cond. (μS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/l)	Temp. (°C)	Salinity (%)	
GW-01	13.Nov.01	6.7	1670	0	0.00	25.0	0.07	16:00 hrs. Clear water, artesian, sunny and hot.
GW-01	19.Dec.01	6.6	1610	0	0.03	24.9	0.07	11:00 hrs. Clear water, artesian, sunny and hot.
GW-01	16.Jan.02	6.4	1450	0	0.11	24.8	0.06	13:00 hrs. Clear water, artesian, cloudy and warm.
GW-01	19.Feb.02	6.7	1620	0	0.03	24.8	0.07	07:45 hrs. Clear water, artesian, cloudy and cool.
GW-01	19.Mar.02	6.5	1680	0	0.00	25.1	0.07	09:30 hrs. Clear water, artesian, warm & sunny.
GW-01	18.Apr.02	6.9	1670	0	0.00	25.0	0.07	08:30 hrs. Clear water, artesian, warm and sunny.
GW-01	21.May.02	6.3	1650	0	0.07	24.6	0.07	10:10 hrs. Clear water, artesian, warm and sunny.
GW-01	18.June.02	5.9	1530	0	0.10	24.4	0.07	15:20 hrs. Clear water, artesian, warm and sunny.
GW-01	18.July.02	6.5	1660	0	0.08	24.1	0.07	09:54 hrs. Clear water, artesian, cool and sunny.
GW-01	21.Aug.02	6.1	1531	0	0.46	24.7	0.07	17:15 hrs. Clear water, artesian, cool and sunny.
GW-01	18.Sep.02	6.7	1400	3	0.08	24.8	0.06	16:20 hrs. Clear water, artesian, sunny and hot.
GW-01	17.Oct.02	6.3	1620	-	0.15	24.7	0.07	16:20 hrs. Clear water, artesian, sunny and hot.

Appendix L

Baseline Surface Water
Estimates of Daily Stream Loadings

Stream loading at surface water monitoring site SW-02

SW-02	Flow (l/s)	TDS (kg/day)	TSS (kg/day)	Sulphate (kg/day)	Al (kg/day)	Cu (kg/day)	Fe (kg/day)	Pb (kg/day)	U (kg/day)
November	1460	5673	1261	0	25	0	88	3	25
December	1040	2606	1258	-	-	0	-	2	0
January	1130	3135	1764	-	-	0	-	0	0
February	1780	3072	2304	768	46	0	108	0	0
March	2800	7258	2419	-	-	0	-	0	0
April	2900	6307	2523	-	-	0	-	0	0
May	2290	3962	2972	3962	40	0	79	2	40
June	2150	3710	3710	-	-	0	-	2	74
July	900	1579	790	-	-	0	-	0	0
August	590	2557	511	1279	10	0	0	5	0
September	520	1804	226	-	-	5	-	9	0
October	140	710	0	-	-	0	-	4	0
Average	1480	3531	1645	1502	30	0	69	2	12

- incomplete data for calculation of stream loading

Stream loading at surface water monitoring site SW-03

SW-03	Flow (l/s)	TDS (kg/day)	TSS (kg/day)	Sulphate (kg/day)	Al kg/day)	Cu (kg/day)	Fe (kg/day)	Pb (kg/day)	U (kg/day)
November	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-
January	11430	40490	15801	-	-	0	-	0	0
February	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-
May	8200	24797	14170	3542	142	0	354	0	71
June	3150	10886	6804	-	-	0	-	14	0
July	2560	4424	4424	-	-	0	-	0	0
August	2700	16330	2333	5832	163	0	0	23	0
September	1950	14321	1685	-	-	0	-	34	0
October	1860	15267	-	-	-	0	-	16	-
Average	4550	18073	7536	4687	152	0	177	12	12

- incomplete data for calculation of stream loading

Stream loading at surface water monitoring site SW-04

SW-04	Flow l/s	TDS (kg/day)	TSS (kg/day)	Sulphate (kg/day)	Al (kg/day)	Cu (kg/day)	Fe (kg/day)	Pb (kg/day)	U (kg/day)
November	100	648	43	302	1.7	0.0	0	0.3	4.3
December	53	243	55	-	-	0.0	-	0.0	0.0
January	115	477	129	-	-	0.0	-	0.1	0.0
February	394	851	851	340	6.8	0.0	10	0.7	0.0
March	320	415	276	-	-	0.0	-	0.0	0.0
April	154	266	133	-	-	0.0	-	0.0	0.0
May	152	591	263	328	7.9	0.0	5	0.0	3.9
June	73	252	158	-	-	0.0	-	0.0	1.9
July	66	171	57	-	-	0.6	-	0.0	2.9
August	69	537	60	149	1.2	0.0	0	0.6	0.0
September	66	485	57	-	-	1.7	-	1.1	0.0
October	66	485	0	-	-	0.0	-	0.6	0.0
Average	136	452	189	280	4.4	0.2	4	0.3	1.1

- incomplete data for calculation of stream loading

Stream loading at surface water monitoring site SW-05

SW-05	Flow l/s	TDS (kg/day)	TSS (kg/day)	Sulphate (kg/day)	Al (kg/day)	Cu (kg/day)	Fe (kg/day)	Pb (kg/day)	U (kg/day)
November	393	2037	679	0	27	0.0	31	1.4	20
December	423	658	548	-	-	0.0	-	0.4	0
January	501	779	693	-	-	0.0	-	0.0	13
February	886	1148	2679	383	153	0.0	31	0.0	38
March	820	2480	708	-	-	0.0	-	0.0	0
April	670	1158	579	-	-	0.0	-	0.0	0
May	436	565	942	565	4	0.0	15	0.0	0
June	388	335	1341	-	-	0.0	-	0.0	0
July	264	228	228	-	-	0.0	-	0.0	0
August	164	425	0	283	4	0.0	0	0.0	0
September	106	137	46	-	-	0.0	-	0.9	0
October	82	177	0	-	-	0	-	0.0	0
Average	428	844	704	308	47	0.0	19	0.2	6

- incomplete data for calculation of stream loading

Stream loading at surface water monitoring site SW-06

SW-06	Flow l/s	TDS (kg/day)	TSS (kg/day)	Sulphate (kg/day)	Al (kg/day)	Cu (kg/day)	Fe (kg/day)	Pb (kg/day)	U (kg/day)
November	9.6	29	4	0	0	0.0	0	0.01	0.25
December	11.5	34	14	-	-	0.0	-	0.00	0.00
January	14.1	62	62	-	-	0.0	-	0.00	0.12
February	14.6	32	50	19	0	0.0	1	0.00	0.13
March	14.3	25	12	-	-	0.0	-	0.00	0.00
April	13.5	35	12	-	-	0.0	-	0.00	0.00
May	12	26	21	26	0	0.0	0	0.00	0.00
June	9.5	16	21	-	-	0.0	-	0.00	0.00
July	5	19	6	-	-	0.0	-	0.00	0.00
August	3.3	14	0	6	0	0.0	0	0.00	0.00
September	1.7	8	1	-	-	0.0	-	0.00	0.00
October	1.5	8	2	-	-	0.0	-	0.00	0.00
Average	9.2	26	17	13	0	0.0	0	0.00	0.04

- incomplete data for calculation of stream loading

Stream loading at surface water monitoring site SW-07

SW/07	Flow l/s	TDS (kg/day)	TSS (kg/day)	Sulphate (kg/day)	Al (kg/day)	Cu (kg/day)	Fe (kg/day)	Pb (kg/day)	U (kg/day)
November	316	1365	137	0	11	0	8	0	19
December	449	1552	543	-	-	0	-	0	0
January	728	2013	252	-	-	0	-	0	19
February	959	1657	1657	1243	25	0	58	0	17
March	1,800	3888	778	-	-	0	-	0	0
April	1,590	3434	1374	-	-	0	-	0	0
May	1,117	2413	1448	1930	10	0	29	0	0
June	886	1914	1531	-	-	0	-	0	15
July	504	1089	435	-	-	0	-	0	4
August	336	1452	0	435	3	0	0	3	0
September	131	849	113	-	-	1	-	1	0
October	68	505	0	-	-	0	-	1	
Average	740	1844	689	902	12	0.1	24	0.4	6.7

- incomplete data for calculation of stream loading

Appendix M

Baseline Geochemical Analysis
Stream Sediment
&
Dissolved Metal Analysis
Sediment Pore Water

Geochemical Analysis of Stream Sediment (aqua-regia cold leach)

Sampling Point	Sample No.	Sampling Date	Element Concentration (mg/kg)										
			Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe
SED-01	Lum/SS/01	13.Nov.01	3,530	6	1,740	<1	<1	<1	2	<1	<1	840	6,820
SED-02	Lum/SS/02	13.Nov.01	2,630	2	1,450	<1	3	<1	4	<1	<1	18	820
SED-03	Lum/SS/03	13.Nov.01	1,020	4	1,310	330	<1	<1	<1	<1	<1	<1	<1
SED-04	Lum/SS/04	27.Nov.01	360	<1	<5	180	<1	230	<1	2	15	18	610
SED-05	Lum/SS/05	14.Nov.01	2,800	<1	1,260	<1	<1	<1	<1	<1	<1	<1	4,800
SED-06	Lum/SS/06	14.Nov.01	2,100	4	1,140	<1	<1	<1	2	<1	<1	<1	1,640
SED-07	Lum/SS/07	14.Nov.01	3,090	<1	1,050	<1	<1	17,100	2	<1	<1	<1	2,040
Sampling Point	**Sample No.**	**Sampling Date**	**Element Concentration (mg/kg)**										
			Hg	**Mg**	**Mn**	**Mo**	**Ni**	**Pb**	**Se**	**V**	**Zn**	**U**	
SED-01	Lum/SS/01	13.Nov.01	<1	<1	41	<1	<1	<1	1	<1	<1	140	
SED-02	Lum/SS/02	13.Nov.01	<1	<1	16	<1	<1	<1	<1	6	120	130	
SED-03	Lum/SS/03	13.Nov.01	<1	<1	<1	64	2	<1	2	5	<1	1,120	
SED-04	Lum/SS/04	27.Nov.01	2	<1	10	<1	<1	2	1	4	3	18	
SED-05	Lum/SS/05	14.Nov.01	<1	<1	42	<1	<1	<1	<1	17	<1	1,490	
SED-06	Lum/SS/06	14.Nov.01	<1	<1	13	39	<1	<1	<1	<1	<1	690	
SED-07	Lum/SS/07	14.Nov.01	<1	<1	22	71	<1	<1	<1	20	12	330	

N.B. Stream sediment sampling points coincide with surface water monitoring sites

Stream Sediment - Pore Water Analysis

Sampling Point	Sample No.	Sampling Date	Total Dissolved Solids and Dissolved Metals										
			TDS mg/l	D.Al mg/l	D.As mg/l	D.B mg/l	D.Ba mg/l	D.Be mg/l	D.Zn mg/l	D.Ca mg/l	D.Cd mg/l	D.Co mg/l	D.Cr mg/l
SED-01	Lum/SS/01	13.Nov.01	210	5	0.24	<5	0.1	<0.1	<0.1	0.1	<0.01	0.1	<0.1
SED-02	Lum/SS/02	13.Nov.01	70	9	0.41	<5	<0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1
SED-03	Lum/SS/03	13.Nov.01	105	2	0.05	<5	<0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1
SED-04	Lum/SS/04	27.Nov.01	110	0.7	<0.01	5	<0.1	<0.1	<0.1	2	<0.01	<0.1	<0.1
SED-05	Lum/SS/05	14.Nov.01	100	21	<0.01	<5	<0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1
SED-06	Lum/SS/06	14.Nov.01	105	35	0.24	<5	0.2	<0.1	0.1	0.2	<0.01	<0.1	<0.1
SED-07	Lum/SS/07	14.Nov.01	125	9	0.62	<5	0.1	<0.1	<0.1	<0.1	<0.01	<0.1	<0.1

Sampling Point	Sample No.	Sampling Date	Total Dissolved Solids and Dissolved Metals										
			D.Cu mg/l	D.Fe mg/l	D.Hg mg/l	D.Mg mg/l	D.Mn mg/l	D.Mo mg/l	D.Ni mg/l	D.Pb mg/l	D.Se mg/l	D.V mg/l	D.U mg/l
SED-01	Lum/SS/01	13.Nov.01	0.1	3	0.01	17	5	<0.1	0.1	0.05	0.07	<0.1	<0.1
SED-02	Lum/SS/02	13.Nov.01	0.1	2	<0.001	<0.1	0.2	0.1	<0.1	0.07	0.12	<0.1	<0.1
SED-03	Lum/SS/03	13.Nov.01	0.1	2	<0.001	<0.1	0.1	<0.1	<0.1	0.03	0.06	<0.1	<0.1
SED-04	Lum/SS/04	27.Nov.01	0.1	<0.1	<0.001	<0.1	0.1	0.1	<0.1	<0.01	<0.01	<0.1	0.6
SED-05	Lum/SS/05	14.Nov.01	0.3	8	<0.001	<0.1	0.1	<0.1	<0.1	0.03	0.18	<0.1	<0.1
SED-06	Lum/SS/06	14.Nov.01	0.5	7	<0.001	<0.1	0.1	<0.1	<0.1	0.36	0.03	<0.1	<0.1
SED-07	Lum/SS/07	14.Nov.01	0.2	4	<0.001	<0.1	0.1	<0.1	<0.1	0.04	0.02	<0.1	<0.1

N.B. Stream sediment sampling points coincide with surface water monitoring sites

Appendix N

USEPA Field Data Sheets for Rapid Bio-assessment of the Aquatic Environment (Surface Water Monitoring Sites)

PHYSICAL CHARACTERISATION -WATER QUALITY FIELD DATA SHEET

STREAM NAME : Chimiwungo Stream	**LOCATION**: New Bridge
STATION #: Mal/AQF-01	**STREAM CLASS:** 3
FORM COMPLETED BY: Henry Chikwala and Nyundo Armitage **DATE:** 25/01/02 **TIME:** 10:00 hrs	
UTM E: 373183 **UTM N:** 8645623	**REASON FOR SURVEY:** Lumwana Copper Project - EIA

SITE PHOTOGRAPH:

WEATHER CONDITIONS

Now:	Past 24 hours:
☐ Rain (steady rain)	☐ Rain (steady rain)
☒ Showers (intermittent)	☒ Showers (intermittent)
☐ Clear / Sunny	☐ Clear / Sunny
Cloud cover: 80 %	Cloud cover: 75 %

Has there been heavy rain the last 7 days?: ☒ YES ☐ NO

Air temperature: 25 °C **Other**:

STREAM CHARACTERISATION	**Stream subsystem:** ☒ Perennial ☐ Intermittent ☐ Tidal **Stream origin:** ☐ Glacial ☒ Spring fed ☐ Non-Glacial montane ☐ Mixture of origins ☐ Swamp and bog ☐ Other **Stream type:** ☒ Warm water ☐ Cold water **Catchment area:** 20 km^2
WATERSHED FEATURES	**Predominant surrounding land-use:** ☒ Forest ☐ Commercial ☐ Field / Pasture ☐ Industrial ☐ Agricultural ☐ Other ☐ Residential **Local watershed NPS pollution:** ☒ No evidence ☐ Potential sources ☐ Obvious sources **Local watershed erosion:** ☒ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Dominant vegetation type.** ☐ Trees ☐ Shrubs ☒ Grasses ☐ Hebaceous **Dominant species present** *Loudetia* and *Hyparrhenia*
INSTREAM FEATURES	**Estimated reach length**: 10,000 m **Estimated stream width**: 1.86 m **Sampling reach area**: 18,600 m^2 **Area in km^2**: 0.0186 km^2 **Estimated stream depth**: 0.68 m **Flow rate** : 1.14 m/sec **Channelled**: ☐ YES ☒ NO **Canopy cover:** ☒ Partly open ☐ Partly shaded ☐ Shaded **High water mark:** 3.0 m **Proportion of reach represented by stream morphology types:** Riffle: 20 % Run: 10 % Pool: 70 % **Dam present**: ☐ YES ☒ NO
LARGE WOODY DEBRIS - LWD	**LWD**: None **Density of LWD**: N/A
AQUATIC VEGETATION	**Dominant type:** ☐ Rooted emergent ☒ Rooted submergent ☐ Rooted floating ☐ Free floating ☐ Floating algae ☐ Attached algae **Dominant species:** not identified **Portion of reach with aquatic vegetation:** 5 %
WATER QUALITY	**Temperature:** 19.8 °C **Specific conductance:** 0.01mS/cm **Dissolved oxygen:** 8.5 mg/l **pH**: 6.2 **Turbidity**: 0 NTU **WQ Instrument:** Horiba U 10 WQC **Water Odours:** ☒ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other **Water surface oils:** ☒ None ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ Other

	Turbidity (if not measured): ☒ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other
SEDIMENT / SUBSTRATE	**Odours**: ☐ Slight ☐ Moderate ☐ Profuse ☐ Chemical ☒ None ☐ Other **Deposits:** ☐ Sewage ☐ Petroleum ☐ Sludge ☐ Sawdust ☐ Paper fiber ☒ Sand ☐ Relict shells ☐ Organic ☐ Other **Substrate composition:** Inorganic: 100 % Organic 0%

Inorganic substrate composition: (should add up to 100 %)			**Organic substrate composition:** (does not necessarily add up to 100)		
Substrate type	Diameter (mm)	Composition in sampling reach	Substrate type	Description	Composition in sampling reach
Bedrock			Detritus	Sticks, wood, coarse plant material.	0 %
Boulder	> 256				
Cobble	64-256	5%	Muck-Mud	Black very fine organic material.	0 %
Gravel	2-64	15%			
Sand	0.06-2	60 %	Marl	Grey, shell fragments.	0%
Silt	0.004-0.06	15 %			
Clay	< 0.004	5 %			

HABITAT ASSESSMENT FIELD DATA SHEET - LOW GRADIENT STREAMS

Habitat Parameter	Condition Category			
	Optimal	**Sub-optimal**	**Marginal**	**Poor**
1. Epifaunal substrate / available cover	Greater than 50% of substrate favorable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonisation potential (i.e., logs / snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation.	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 **17** 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool substrate characterisation	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation
SCORE	20 **19** 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small - shallow or pools absent.
SCORE	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 **17** 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel flow status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 **17** 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel alteration	Channelling or dredging absent or minimal; stream with normal pattern.	Some channelling present, usually in areas of bridge abutments; evidence of past channelling, i.e., dredging, (greater than past 20 yr) may be present, but recent channelling is not present.	Channelling may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelled and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelled and disrupted. Instream habitat greatly altered or removed entirely
SCORE	20 19 18 17 16	15 14 **13** 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelled for a long distance.
SCORE	20 19 18 17 16	**15** 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

8. Bank stability (Score for each bank. Determine left or right side by facing downstream).	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE, Left bank	10 9	8 **7** 6	5 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0
9. Vegetative protection. (Score for each bank)	More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or non-woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the stream bank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE, Left bank	**10** 9	8 7 6	5 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0
10. Riparian vegetative zone width. (Score for each bank).	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12- 18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6 - 12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE, Left bank	**10** 9	8 7 6	5 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0

AVERAGE SCORE	**17.5**	
TOTAL SCORE	**175**	**OPTIMAL HABITAT**

PHYSICAL CHARACTERISATION -WATER QUALITY FIELD DATA SHEET

STREAM NAME : Lumwana East River	**LOCATION**: Malundwe Site (Stanley Drilling Camp)
STATION #: Mal/AQF-02	**STREAM CLASS:** 4
FORM COMPLETED BY: Henry Chikwala and Nyundo Armitage **DATE:** 25/01/02 **TIME:** 12:00 hrs	
UTM E: 372235 **UTM N:** 8646296	**REASON FOR SURVEY:** Lumwana Copper Project - EIA

SITE PHOTOGRAPH:

WEATHER CONDITIONS	**Now:**	**Past 24 hours:**
	☐ Rain (steady rain)	☐ Rain (steady rain)
	☒ Showers (intermittent)	☒ Showers (intermittent)
	☐ Clear / Sunny	☐ Clear / Sunny
	Cloud cover: 20 %	Cloud cover: 70 %
	Has there been heavy rain the last 7 days?: ☒ YES ☐ NO	
	Air temperature: 27 °C **Other**:	

HABITAT ASSESSMENT FIELD DATA SHEET - LOW GRADIENT STREAMS

Habitat Parameter	Condition Category			
	Optimal	**Sub-optimal**	**Marginal**	**Poor**
1. Epifaunal substrate / available cover	Greater than 50% of substrate favorable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonisation potential (i.e., logs / snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation.	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 **11**	10 9 8 7 6	5 4 3 2 1 0
2. Pool substrate characterisation	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation
SCORE	20 19 **18** 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small - shallow or pools absent.
SCORE	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel flow status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel alteration	Channelling or dredging absent or minimal; stream with normal pattern.	Some channelling present, usually in areas of bridge abutments; evidence of past channelling, i.e., dredging, (greater than past 20 yr) may be present, but recent channelling is not present.	Channelling may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelled and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelled and disrupted. Instream habitat greatly altered or removed entirely
SCORE	20 19 18 17 16	**15** 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelled for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 **9** 8 7 6	5 4 3 2 1 0

	Turbidity (if not measured): ☐ Clear ☒ Slightly turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other
SEDIMENT / SUBSTRATE	**Odours**: ☐ Slight ☐ Moderate ☐ Profuse ☐ Chemical ☒ None ☐ Other **Deposits:** ☐ Sewage ☐ Petroleum ☐ Sludge ☐ Sawdust ☐ Paper fiber ☒ Sand ☐ Relict shells ☐ Organic ☐ Other **Substrate composition:** Inorganic: 100 % Organic 0%

Inorganic substrate composition: (should add up to 100 %)			**Organic substrate composition:** (does not necessarily add up to 100)		
Substrate type	Diameter (mm)	Composition in sampling reach	Substrate type	Description	Composition in sampling reach
Bedrock			Detritus	Sticks, wood, coarse plant material.	0 %
Boulder	> 256				
Cobble	64-256	10%	Muck-Mud	Black very fine organic material.	0 %
Gravel	2-64	15%			
Sand	0.06-2	55 %	Marl	Grey, shell fragments.	0%
Silt	0.004-0.06	15 %			
Clay	< 0.004	5 %			

STREAM CHARACTERISATION	**Stream subsystem:** ☒ Perennial ☐ Intermittent ☐ Tidal **Stream origin:** ☐ Glacial ☐ Spring fed ☐ Non-Glacial montane ☒ Mixture of origins ☐ Swamp and bog ☐ Other	**Stream type:** ☒ Warm water ☐ Cold water **Catchment area:** 150 km^2
WATERSHED FEATURES	**Predominant surrounding land-use:** ☒ Forest ☐ Commercial ☐ Field / Pasture ☐ Industrial ☐ Agricultural ☒ Other (Miombo/Riverine) ☐ Residential	**Local watershed NPS pollution:** ☒ No evidence ☐ Potential sources ☐ Obvious sources **Local watershed erosion:** ☐ None ☒ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Dominant vegetation type.** ☒ Trees ☐ Shrubs ☐ Grasses ☐ Hebaceous **Dominant species present** *Syzygium Cordatum & Bridelia Micrantha*	
INSTREAM FEATURES	**Estimated reach length**: 30,000 m **Estimated stream width**: 4.00 m **Sampling reach area**: 120,000 m^2 **Area in km^2**: 0.12 km^2 **Estimated stream depth**: 1.00 m **Flow rate** : 1.35 m/sec **Channelled**: ☐ YES ☒ NO	**Canopy cover:** ☐ Partly open ☒ Partly shaded ☐ Shaded **High water mark:** 2.0 m **Proportion of reach represented by stream morphology types:** Riffle: 60 % Run: 10 % Pool: 30 % **Dam present**: ☐ YES ☒ NO
LARGE WOODY DEBRIS - LWD	**LWD**: None **Density of LWD**: N/A	
AQUATIC VEGETATION	**Dominant type:** ☐ Rooted emergent ☒ Rooted submergent ☐ Rooted floating ☐ Free floating ☐ Floating algae ☐ Attached algae **Dominant species:** Tiger Lilies **Portion of reach with aquatic vegetation:** 5 %	
WATER QUALITY	**Temperature:** 20.2 °C **Specific conductance:** 0.019mS/cm **Dissolved oxygen:** 8.9 mg/l **pH**: 5.9 **Turbidity**: 0 NTU **WQ Instrument:** Horiba U 10 WQC **Water Odours:** ☒ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other **Water surface oils:** ☒ None ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ Other	

8. Bank stability (Score for each bank. Determine left or right side by facing downstream).	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE, Left bank	10 9	**8** 7 6	5 4 3	2 1 0
SCORE, Right bank	10 9	**8** 7 6	5 4 3	2 1 0
9. Vegetative protection. (Score for each bank)	More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or non-woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the stream bank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE, Left bank	10 9	**8** 7 6	5 4 3	2 1 0
SCORE, Right bank	10 9	**8** 7 6	5 4 3	2 1 0
10. Riparian vegetative zone width. (Score for each bank).	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12- 18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6 - 12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE, Left bank	10 9	**8** 7 6	5 4 3	2 1 0
SCORE, Right bank	10 **9**	8 7 6	5 4 3	2 1 0

AVERAGE SCORE	**16.2**	
TOTAL SCORE	**162**	**OPTIMAL HABITAT**

PHYSICAL CHARACTERISATION -WATER QUALITY FIELD DATA SHEET

STREAM NAME : Kababisa Stream	**LOCATION**: Kababisa Dambo
STATION #: Mal/AQF-03	**STREAM CLASS:** 3
FORM COMPLETED BY: Henry Chikwala and Nyundo Armitage **DATE:** 25/01/02 **TIME:** 15:00 hrs	
UTM E: 375047 **UTM N:** 8648662	**REASON FOR SURVEY:** Lumwana Copper Project - EIA

SITE PHOTOGRAPH:

WEATHER CONDITIONS	**Now:**	**Past 24 hours:**
	☐ Rain (steady rain)	☐ Rain (steady rain)
	☒ Showers (intermittent)	☒ Showers (intermittent)
	☐ Clear / Sunny	☐ Clear / Sunny
	Cloud cover: 50 %	Cloud cover: 70 %
	Has there been heavy rain the last 7 days?: ☒ YES ☐ NO	
	Air temperature: 26 °C **Other**:	

STREAM CHARACTERISATION	**Stream subsystem:** ☐ Perennial ☒ Intermittent ☐ Tidal **Stream origin:** ☐ Glacial ☐ Spring fed ☐ Non-Glacial montane ☒ Mixture of origins ☐ Swamp and bog ☐ Other	**Stream type:** ☒ Warm water ☐ Cold water **Catchment area:** 25 km^2
WATERSHED FEATURES	**Predominant surrounding land-use:** ☐ Forest ☐ Commercial ☐ Field / Pasture ☐ Industrial ☐ Agricultural ☒ Other (Seepage Dambo) ☐ Residential	**Local watershed NPS pollution:** ☒ No evidence ☐ Potential sources ☐ Obvious sources **Local watershed erosion:** ☒ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Dominant vegetation type.** ☐ Trees ☒ Shrubs ☒ Grasses ☐ Hebaceous **Dominant species present** *Phragmites mauritania* and *Hyparrhenia rufa*	
INSTREAM FEATURES	**Estimated reach length**: 5,000 m **Estimated stream width**: 2.00 m **Sampling reach area**: 10,000 m^2 **Area in km^2**: 0.01 km^2 **Estimated stream depth**: 0.37 m **Flow rate** : 1.00 m/sec **Channelled**: ☐ YES ☒ NO	**Canopy cover:** ☒ Partly open ☐ Partly shaded ☐ Shaded **High water mark:** 0.5 m **Proportion of reach represented by stream morphology types:** Riffle: 10 % Run: 70 % Pool: 20 % **Dam present**: ☐ YES ☒ NO
LARGE WOODY DEBRIS - LWD	**LWD**: None **Density of LWD**: N/A	
AQUATIC VEGETATION	**Dominant type:** ☒ Rooted emergent ☒ Rooted submergent ☒ Rooted floating ☒ Free floating ☐ Floating algae ☐ Attached algae **Dominant species:** Water Lilies **Portion of reach with aquatic vegetation:** 5 %	
WATER QUALITY	**Temperature:** 20.9 °C **Specific conductance:** 0.037mS/cm **Dissolved oxygen:** 6.9 mg/l **pH**: 5.8 **Turbidity**: 0 NTU **WQ Instrument:** Horiba U 10 WQC **Water Odours:** ☒ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other **Water surface oils:** ☒ None ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ Other	

<table>
<tr><td></td><td>Turbidity (if not measured):

☐ Clear ☒ Slightly turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other</td></tr>
<tr><td>SEDIMENT / SUBSTRATE</td><td>Odours:

☐ Slight ☐ Moderate ☐ Profuse ☐ Chemical ☒ None ☐ Other

Deposits:

☐ Sewage ☐ Petroleum ☐ Sludge ☐ Sawdust ☐ Paper fiber ☒ Sand
☐ Relict shells ☐ Organic ☐ Other

Substrate composition: Inorganic: 100 % Organic 0%</td></tr>
</table>

<table>
<tr><td colspan="3">Inorganic substrate composition:
(should add up to 100 %)</td><td colspan="3">Organic substrate composition:
(does not necessarily add up to 100)</td></tr>
<tr><td>Substrate type</td><td>Diameter (mm)</td><td>Composition in sampling reach</td><td>Substrate type</td><td>Description</td><td>Composition in sampling reach</td></tr>
<tr><td>Bedrock
Boulder
Cobble
Gravel
Sand
Silt
Clay</td><td>
> 256
64-256
2-64
0.06-2
0.004-0.06
< 0.004</td><td>

60 %
35 %
5 %</td><td>Detritus

Muck-Mud

Marl</td><td>Sticks, wood, coarse plant material.

Black very fine organic material.

Grey, shell fragments.</td><td>0 %

0 %

0%</td></tr>
</table>

HABITAT ASSESSMENT FIELD DATA SHEET - LOW GRADIENT STREAMS

Habitat Parameter	Condition Category			
	Optimal	**Sub-optimal**	**Marginal**	**Poor**
1. Epifaunal substrate / available cover	Greater than 50% of substrate favorable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonisation potential (i.e., logs / snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation.	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 **16**	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool substrate characterisation	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation
SCORE	20 19 18 17 16	15 **14** 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small - shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	**5** 4 3 2 1 0
4. Sediment deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 **17** 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel flow status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel alteration	Channelling or dredging absent or minimal; stream with normal pattern.	Some channelling present, usually in areas of bridge abutments; evidence of past channelling, i.e., dredging, (greater than past 20 yr) may be present, but recent channelling is not present.	Channelling may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelled and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelled and disrupted. Instream habitat greatly altered or removed entirely
SCORE	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelled for a long distance.
SCORE	20 19 18 17 **16**	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

8. Bank stability (Score for each bank. Determine left or right side by facing downstream).	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE, Left bank	10 9	**8** 7 6	5 4 3	2 1 0
SCORE, Right bank	10 9	8 7 6	**5** 4 3	2 1 0
9. Vegetative protection. (Score for each bank)	More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or non-woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the stream bank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE, Left bank	10 9	8 7 **6**	5 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0
10. Riparian vegetative zone width. (Score for each bank).	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12- 18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6 - 12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE, Left bank	10 9	8 7 6	**5** 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0

AVERAGE SCORE	**15.2**	
TOTAL SCORE	**152**	**OPTIMAL HABITAT**

PHYSICAL CHARACTERISATION -WATER QUALITY FIELD DATA SHEET

STREAM NAME : Malundwe Stream	**LOCATION**: Close to confluence with the Lumwana East River
STATION #: Mal/AQF-04	**STREAM CLASS:** 4
FORM COMPLETED BY: Henry Chikwala and Nyundo Armitage **DATE:** 26/01/02 **TIME:** 09:50 hrs	
UTM E: 369212 **UTM N:** 8647264	**REASON FOR SURVEY:** Lumwana Copper Project - EIA

SITE PHOTOGRAPH:

WEATHER CONDITIONS

Now:	Past 24 hours:
☐ Rain (steady rain)	☐ Rain (steady rain)
☐ Showers (intermittent)	☒ Showers (intermittent)
☒ Clear / Sunny	☐ Clear / Sunny
Cloud cover: 20 %	Cloud cover: 70 %

Has there been heavy rain the last 7 days?: ☒ YES ☐ NO

Air temperature: 26 °C **Other**:

STREAM CHARACTERISATION	**Stream subsystem:** ☒ Perennial ☐ Intermittent ☐ Tidal **Stream origin:** ☐ Glacial ☐ Spring fed ☐ Non-Glacial montane ☒ Mixture of origins ☐ Swamp and bog ☐ Other	**Stream type:** ☒ Warm water ☐ Cold water **Catchment area:** 150 km^2
WATERSHED FEATURES	**Predominant surrounding land-use:** ☒ Forest ☐ Commercial ☐ Field / Pasture ☐ Industrial ☐ Agricultural ☒ Other (Miombo/Riverine) ☐ Residential	**Local watershed NPS pollution:** ☒ No evidence ☐ Potential sources ☐ Obvious sources **Local watershed erosion:** ☒ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Dominant vegetation type.** ☒ Trees ☐ Shrubs ☒ Grasses ☐ Hebaceous **Dominant species present** *Syzygium Cordatum & Bridelia Micrantha*	
INSTREAM FEATURES	**Estimated reach length**: 150,000 m **Estimated stream width**: 7.00 m **Sampling reach area**: 1,050,000 m^2 **Area in km^2**: 1,050 km^2 **Estimated stream depth**: 0.67 m **Flow rate** : 1.35 m/sec **Channelled**: ☐ YES ☒ NO	**Canopy cover:** ☐ Partly open ☐ Partly shaded ☒ Shaded **High water mark:** 1.00 m **Proportion of reach represented by stream morphology types:** Riffle: 60 % Run: 10 % Pool: 30 % **Dam present**: ☐ YES ☒ NO
LARGE WOODY DEBRIS - LWD	**LWD**: None **Density of LWD**: N/A	
AQUATIC VEGETATION	**Dominant type:** ☐ Rooted emergent ☒ Rooted submergent ☒ Rooted floating ☒ Free floating ☐ Floating algae ☐ Attached algae **Dominant species:** Tiger Lilies **Portion of reach with aquatic vegetation:** 5 %	
WATER QUALITY	**Temperature:** 20.6 °C **Specific conductance:** 0.017mS/cm **Dissolved oxygen:** 8.5 mg/l **pH**: 6.5 **Turbidity**: 2.9 NTU **WQ Instrument:** Horiba U 10 WQC **Water Odours:** ☒ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other **Water surface oils:** ☒ None ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ Other	

	Turbidity (if not measured): Clear ☐ Slightly turbid ☒ Turbid ☐ Opaque ☐ Stained ☐ Other ☐
SEDIMENT / SUBSTRATE	**Odours**: Slight ☐ Moderate ☐ Profuse ☐ Chemical ☐ None ☒ Other ☐ **Deposits:** Sewage ☐ Petroleum ☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand ☒ Relict shells ☐ Organic ☐ Other ☐ **Substrate composition:** Inorganic: 100 % Organic 0%

Inorganic substrate composition:
(should add up to 100 %)

Organic substrate composition:
(does not necessarily add up to 100)

Substrate type	Diameter (mm)	Composition in sampling reach	Substrate type	Description	Composition in sampling reach
Bedrock			Detritus	Sticks, wood, coarse plant material.	0 %
Boulder	> 256				
Cobble	64-256	5%	Muck-Mud	Black very fine organic material.	0 %
Gravel	2-64	15%			
Sand	0.06-2	65 %	Marl	Grey, shell fragments.	0%
Silt	0.004-0.06	10 %			
Clay	< 0.004	5 %			

HABITAT ASSESSMENT FIELD DATA SHEET - LOW GRADIENT STREAMS

Habitat Parameter	Condition Category			
	Optimal	**Sub-optimal**	**Marginal**	**Poor**
1. Epifaunal substrate / available cover	Greater than 50% of substrate favorable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonisation potential (i.e., logs / snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation.	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool substrate characterisation	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small - shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel flow status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel alteration	Channelling or dredging absent or minimal; stream with normal pattern.	Some channelling present, usually in areas of bridge abutments; evidence of past channelling, i.e., dredging, (greater than past 20 yr) may be present, but recent channelling is not present.	Channelling may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelled and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelled and disrupted. Instream habitat greatly altered or removed entirely
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelled for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

8. Bank stability (Score for each bank. Determine left or right side by facing downstream).	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE, Left bank	**10** 9	8 7 6	5 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0
9. Vegetative protection. (Score for each bank)	More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or non-woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the stream bank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE, Left bank	**10** 9	8 7 6	5 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0
10. Riparian vegetative zone width. (Score for each bank).	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12- 18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6 - 12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE, Left bank	**10** 9	8 7 6	5 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0

AVERAGE SCORE	**19.6**	
TOTAL SCORE	**196**	**OPTIMAL HABITAT**

PHYSICAL CHARACTERISATION -WATER QUALITY FIELD DATA SHEET

STREAM NAME : Chimiwungo Stream	**LOCATION**: Bridge crossing at Chimiwungo Main Pit
STATION #: Chim/AQF-01	**STREAM CLASS:** 3
FORM COMPLETED BY: Henry Chikwala and Nyundo Armitage **DATE:** 26/01/02 **TIME:** 12:35 hrs	
UTM E: 377700 **UTM N:** 8642182	**REASON FOR SURVEY:** Lumwana Copper Project - EIA

SITE PHOTOGRAPH:

WEATHER CONDITIONS	**Now:**	**Past 24 hours:**
	☐ Rain (steady rain)	☒ Rain (steady rain)
	☒ Showers (intermittent)	☐ Showers (intermittent)
	☐ Clear / Sunny	☐ Clear / Sunny
	Cloud cover: 80 %	Cloud cover: 75 %
	Has there been heavy rain the last 7 days?: ☒ YES ☐ NO	
	Air temperature: 24 °C **Other**:	

STREAM CHARACTERISATION	**Stream subsystem:** ☒ Perennial ☐ Intermittent ☐ Tidal **Stream origin:** ☐ Glacial ☒ Spring fed ☐ Non-Glacial montane ☐ Mixture of origins ☐ Swamp and bog ☐ Other	**Stream type:** ☒ Warm water ☐ Cold water **Catchment area:** 150 km^2
WATERSHED FEATURES	**Predominant surrounding land-use:** ☒ Forest ☐ Commercial ☐ Field / Pasture ☐ Industrial ☐ Agricultural ☒ Other (Miombo/Riverine) ☐ Residential	**Local watershed NPS pollution:** ☒ No evidence ☐ Potential sources ☐ Obvious sources **Local watershed erosion:** ☒ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Dominant vegetation type.** ☐ Trees ☒ Shrubs ☒ Grasses ☐ Hebaceous **Dominant species present** *Phragmites mauritania* and *Hyparrhenia rufa*	
INSTREAM FEATURES	**Estimated reach length**: 3,000 m **Estimated stream width**: 1.35 m **Sampling reach area**: 4,050 m^2 **Area in km^2**: 0.00405 km^2 **Estimated stream depth**: 0.35 m **Flow rate** : 0.5 m/sec **Channelled**: ☐ YES ☒ NO	**Canopy cover:** ☒ Partly open ☐ Partly shaded ☐ Shaded **High water mark:** 0.50 m **Proportion of reach represented by stream morphology types:** Riffle: 20 % Run: 30 % Pool: 50 % **Dam present**: ☐ YES ☒ NO
LARGE WOODY DEBRIS - LWD	**LWD**: None **Density of LWD**: N/A	
AQUATIC VEGETATION	**Dominant type:** ☒ Rooted emergent ☒ Rooted submergent ☒ Rooted floating ☒ Free floating ☐ Floating algae ☐ Attached algae **Dominant species:** Water Lilies **Portion of reach with aquatic vegetation:** 5 %	
WATER QUALITY	**Temperature:** 19.8 °C **Specific conductance:** 0.015mS/cm **Dissolved oxygen:** 7.9 mg/l **pH**: 6.3 **Turbidity**: 0 NTU **WQ Instrument:** Horiba U 10 WQC **Water Odours:** ☒ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other **Water surface oils:** ☒ None ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ Other	

	Turbidity (if not measured): ☒ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other
SEDIMENT / SUBSTRATE	**Odours**: ☐ Slight ☐ Moderate ☐ Profuse ☐ Chemical ☒ None ☐ Other **Deposits:** ☐ Sewage ☐ Petroleum ☐ Sludge ☐ Sawdust ☐ Paper fiber ☒ Sand ☐ Relict shells ☐ Organic ☐ Other **Substrate composition:** Inorganic: 100 % Organic 0%

Inorganic substrate composition: (should add up to 100 %)			**Organic substrate composition:** (does not necessarily add up to 100)		
Substrate type	Diameter (mm)	Composition in sampling reach	Substrate type	Description	Composition in sampling reach
Bedrock			Detritus	Sticks, wood, coarse plant material.	0 %
Boulder	> 256				
Cobble	64-256		Muck-Mud	Black very fine organic material.	0 %
Gravel	2-64				
Sand	0.06-2	55 %	Marl	Grey, shell fragments.	0%
Silt	0.004-0.06	30 %			
Clay	< 0.004	15 %			

HABITAT ASSESSMENT FIELD DATA SHEET - LOW GRADIENT STREAMS

Habitat Parameter	Condition Category			
	Optimal	**Sub-optimal**	**Marginal**	**Poor**
1. Epifaunal substrate / available cover	Greater than 50% of substrate favorable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonisation potential (i.e., logs / snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation.	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 **18** 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool substrate characterisation	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation
SCORE	20 19 18 17 16	15 **14** 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small - shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	**10** 9 8 7 6	5 4 3 2 1 0
4. Sediment deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel flow status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel alteration	Channelling or dredging absent or minimal; stream with normal pattern.	Some channelling present, usually in areas of bridge abutments; evidence of past channelling, i.e., dredging, (greater than past 20 yr) may be present, but recent channelling is not present.	Channelling may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelled and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelled and disrupted. Instream habitat greatly altered or removed entirely
SCORE	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelled for a long distance.
SCORE	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

8. Bank stability (Score for each bank. Determine left or right side by facing downstream).	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE, Left bank	**10** 9	8 7 6	5 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0
9. Vegetative protection. (Score for each bank)	More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or non-woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the stream bank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE, Left bank	**10** 9	8 7 6	5 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0
10. Riparian vegetative zone width. (Score for each bank).	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12- 18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6 - 12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE, Left bank	**10** 9	8 7 6	5 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0

AVERAGE SCORE	**18.2**	
TOTAL SCORE	**182**	**OPTIMAL HABITAT**

PHYSICAL CHARACTERISATION -WATER QUALITY FIELD DATA SHEET

STREAM NAME : Lumwana East River	**LOCATION**: Bridge crossing on T5 main road
STATION #: Lum/AQF-01	**STREAM CLASS:** 5
FORM COMPLETED BY: Henry Chikwala and Nyundo Armitage **DATE:** 26/01/02 **TIME:** 16:05 hrs	
UTM E: 384958 **UTM N:** 8643150	**REASON FOR SURVEY:** Lumwana Copper Project - EIA

SITE PHOTOGRAPH:

WEATHER CONDITIONS

Now:	**Past 24 hours:**
☐ Rain (steady rain)	☐ Rain (steady rain)
☒ Showers (intermittent)	☒ Showers (intermittent)
☐ Clear / Sunny	☐ Clear / Sunny
Cloud cover: 90 %	Cloud cover: 75 %

Has there been heavy rain the last 7 days?: ☒ YES ☐ NO

Air temperature: 24 °C **Other**:

STREAM CHARACTERISATION	**Stream subsystem:** ☒ Perennial ☐ Intermittent ☐ Tidal **Stream origin:** ☐ Glacial ☐ Spring fed ☐ Non-Glacial montane ☒ Mixture of origins ☐ Swamp and bog ☐ Other	**Stream type:** ☒ Warm water ☐ Cold water **Catchment area:** 200 km^2
WATERSHED FEATURES	**Predominant surrounding land-use:** ☒ Forest ☐ Commercial ☐ Field / Pasture ☐ Industrial ☐ Agricultural ☒ Other (Miombo/Riverine) ☐ Residential	**Local watershed NPS pollution:** ☒ No evidence ☐Potential sources ☐ Obvious sources **Local watershed erosion:** ☐None ☒ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	**Dominant vegetation type.** ☒ Trees ☐ Shrubs ☐ Grasses ☐ Hebaceous **Dominant species present** *Syzygium Cordatum & Bridelia Micrantha*	
INSTREAM FEATURES	**Estimated reach length**: 50,000 m **Estimated stream width**: 12 m **Sampling reach area**: 600,000 m^2 **Area in km^2**: 0.60 km^2 **Estimated stream depth**: 1.30 m **Flow rate** : 0.73 m/sec **Channelled**: ☐ YES ☒ NO	**Canopy cover:** ☒ Partly open ☐ Partly shaded ☐ Shaded **High water mark:** river about to flood **Proportion of reach represented by stream morphology types:** Riffle: 15 % Run: 30 % Pool: 55 % **Dam present**: ☐ YES ☒ NO
LARGE WOODY DEBRIS - LWD	**LWD**: None visible **Density of LWD**: N/A	
AQUATIC VEGETATION	**Dominant type:** ☒ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating ☐ Floating algae ☐ Attached algae **Dominant species:** Fragmites mauritania & Cyperus papyrus **Portion of reach with aquatic vegetation:** 5 %	
WATER QUALITY	**Temperature:** 20.6 °C **Specific conductance:** 0.03 mS/cm **Dissolved oxygen:** 7.1 mg/l **pH**: 6.5 **Turbidity**: 10 NTU **WQ Instrument:** Horiba U 10 WQC **Water Odours:** ☒ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other **Water surface oils:** ☒ None ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ Other	

	Turbidity (if not measured): ☐ Clear ☐ Slightly turbid ☐ Turbid ☒ Opaque ☐ Stained ☐ Other
SEDIMENT / SUBSTRATE	**Odours**: ☒ Slight ☐ Moderate ☐ Profuse ☐ Chemical ☐ None ☐ Other **Deposits:** ☐ Sewage ☐ Petroleum ☐ Sludge ☐ Sawdust ☐ Paper fiber ☒ Sand ☐ Relict shells ☒ Organic ☐ Other **Substrate composition:** Inorganic: 80 % Organic 20%

Inorganic substrate composition: (should add up to 100 %)			**Organic substrate composition:** (does not necessarily add up to 100)		
Substrate type	Diameter (mm)	Composition in sampling reach	Substrate type	Description	Composition in sampling reach
Bedrock			Detritus	Sticks, wood, coarse plant material.	60 %
Boulder	> 256				
Cobble	64-256		Muck-Mud	Black very fine organic material.	40 %
Gravel	2-64				
Sand	0.06-2	45 %	Marl	Grey, shell fragments.	0%
Silt	0.004-0.06	35 %			
Clay	< 0.004	20 %			

HABITAT ASSESSMENT FIELD DATA SHEET - LOW GRADIENT STREAMS

Habitat Parameter	Condition Category			
	Optimal	**Sub-optimal**	**Marginal**	**Poor**
1. Epifaunal substrate / available cover	Greater than 50% of substrate favorable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonisation potential (i.e., logs / snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonisation.	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	**15** 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool substrate characterisation	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation
SCORE	20 19 18 **17** 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small - shallow or pools absent.
SCORE	20 19 18 17 16	15 **14** 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 **16**	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel flow status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel alteration	Channelling or dredging absent or minimal; stream with normal pattern.	Some channelling present, usually in areas of bridge abutments; evidence of past channelling, i.e., dredging, (greater than past 20 yr) may be present, but recent channelling is not present.	Channelling may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelled and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelled and disrupted. Instream habitat greatly altered or removed entirely
SCORE	**20** 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelled for a long distance.
SCORE	20 19 18 17 16	15 14 **13** 12 11	10 9 8 7 6	5 4 3 2 1 0

8. Bank stability (Score for each bank. Determine left or right side by facing downstream).	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE, Left bank	**10** 9	8 7 6	5 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0
9. Vegetative protection. (Score for each bank)	More than 90% of the stream bank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or non-woody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the stream bank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the stream bank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the stream bank surfaces covered by vegetation; disruption of stream bank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE, Left bank	**10** 9	8 7 6	5 4 3	2 1 0
SCORE, Right bank	10 **9**	8 7 6	5 4 3	2 1 0
10. Riparian vegetative zone width. (Score for each bank).	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12- 18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6 - 12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE, Left bank	**10** 9	8 7 6	5 4 3	2 1 0
SCORE, Right bank	**10** 9	8 7 6	5 4 3	2 1 0

AVERAGE SCORE	**17.4**	
TOTAL SCORE	**174**	**OPTIMAL HABITAT**

Appendix O

FAO Soil Classification Field Data Sheets
Soil Profile Pits

Profile No.	Mal/SPP-01
Soil Classification	**Acric Ferric Ferralsol (FAO-IRIC-ISSS, 1998)**
Location	Approximately 550metres north of the timber bridge at Lumwana exploration drilling camp. East of southern zone of Malundwe Copper Deposit and 10 metres west of track going north from the river. Northwestern Province of Zambia.
Grid Reference	UTM 35L co-ordinates 372335E 8646760 N
Described by	Mattias Fackel.
Date	11 December 2001.
Elevation	Approximately 1300 O.D.
Relief	Lower slope, 4 kilometres from slope crest and 800 metres from East Lumwana River. Dome structure dissected by streams/rivers and surrounded by gently undulating plateau.
Slope	5 degrees.
Aspect	190°S
Parent Material	Basement schist. Lower Roan and undifferentiated Basement Complex.
Soil Surface	Flat terrain.
Erosion/Deposition	Surface runoff.
Rock Outcrops	None.
Land Use	None.
Vegetation	Wetter Zambezi Broadleaf/Miombo Woodland.
Soil Horizons CEC = Cation Exchange Capacity BSP = Base Saturation Percentage TOC = Total Organic Carbon Percentage in ‘A’ Horizon	0 - 12 cm. Ah Dusky yellowish brown (10YR 2/2), moist loamy sand, apedal, loose when moist, non-sticky and non-plastic when wet, >5% very fine pores, may fine medium fibrous and woody roots, clear smooth boundary. 16% Clay, CEC = 4.48 cmol/kg clay, BSP = 83.4%, TOC = 1.4%
	12 - 20 cm. E Dark reddish brown (10R 3/4), moist loamy sand, slightly stony, very small stones, weak medium granular structure, friable when moist, slightly sticky and non-plastic when wet, 2% very fine pores, common medium fibrous roots, clear smooth boundary. 16% Clay, CEC = 10.9 cmol/kg clay, BSP = 20.8%
	20 - 60 cm. Bw Reddish brown (5YR 5/4), moist sandy clay loam, very stony, medium quartz stones, strong medium granular structure, 2% medium pores, firm when moist, moderately sticky and plastic when wet, few medium roots, dark red (5R 3/6) shiny coatings on quartz fragments, no concretions, gradual smooth boundary. 22% Clay, CEC = 15.2 cmol/kg clay, BSP = 21.7%
	60 - 160 cm. Bw Dark red (5R 3/6), moist extremely stony, quartz gravel and ferro-manganese concretions, strong coarse granular structure, few fine roots, 0.5% medium pores, clay coatings on stones and nodules (5R 3/6) 19% Clay, CEC = 5.2 cmol/kg clay, BSP = 27.9%

Profile No.	**Mal/SPP-02**
Soil Classification	**Dystric Regosol (FAO-IRIC-ISSS, 1998)**
Location	Approximately 7 metres from the north bank of the East Lumwana River, 100 metres downstream from the timber bridge at Lumwana exploration drilling camp, Northwestern Province of Zambia.
Grid Reference	UTM 35L co-ordinates 372215E 8646305 N
Described by	Mattias Fackel.
Date	21 November 2001.
Elevation	Approximately 1300 O.D.
Relief	At bottom of slope approximately 5 kilometres from slope crest. Dome structure dissected by streams/rivers and surrounded by gently undulating plateau.
Slope	18 degrees.
Aspect	180°S
Parent Material	Basement schist. Lower Roan and undifferentiated Basement Complex.
Soil Surface	Flat terrain except for furrows.
Erosion/Deposition	Deposition of alluvium.
Rock Outcrops	None.
Land Use	Maize cultivation.
Vegetation	Maize.
Soil Horizons CEC = Cation Exchange Capacity BSP = Base Saturation Percentage TOC = Total Organic Carbon Percentage in 'A' Horizon	0 - 25 cm. Ah Dark reddish brown (5YR 3/4), moist loamy sand, weak medium crumb structure, friable when moist, slightly sticky and slightly plastic when wet, common fine fibrous roots, diffuse smooth boundary. 19% Clay, CEC = 20.5 cmol/kg clay, BSP = 12.1%, TOC = 3.7%
	25 - 90 cm. B Moderate brown (2.5YR 5/4), fine sandy loam, weak granular coarse structure, friable when moist, slightly sticky and slightly plastic when wet, few fine fibrous roots, diffuse smooth boundary. 17% Clay, CEC = 11.7 cmol/kg clay, BSP = 7.4%
	90 - 150 cm. B Light brown (5YR 5/8), moist loamy sand, micaceous, weak granular structure, friable when moist, slightly sticky and non- plastic when wet. 12% Clay, CEC = 3.5 cmol/kg clay, BSP = 46%

Profile No.	**Chim/SPP-03**
Soil Classification	**Acric Ferralsol (FAO-IRIC-ISSS, 1998)**
Location	Approximately 100 metres down track leading from the Solwezi - Mwinilunga road to the Chimiwungo copper deposit. Northwestern Province of Zambia.
Grid Reference	UTM 35L co-ordinates 377550E 8638890 N
Described by	Mattias Fackel.
Date	25 November 2001.
Elevation	Approximately 1350 O.D.
Relief	Level terrain, below and south of higher terrain dissected by streams. Dome structure surrounded by gently undulating plateau.
Slope	No slope.
Aspect	n/a
Parent Material	Basement schist. Lower Roan and undifferentiated Basement Complex.
Soil Surface	Flat terrain, even soil surface, some exposed areas of soil.
Erosion/Deposition	None evident.
Rock Outcrops	None.
Land Use	No apparent land use.
Vegetation	Wetter Zambezi Broadleaf/Miombo woodland.
Soil Horizons CEC = Cation Exchange Capacity BSP = Base Saturation Percentage TOC = Total Organic Carbon Percentage in 'A' Horizon	0 - 15 cm. Ah Dark yellowish brown (10YR 3/6), moist sandy loam, weak medium granular structure, slightly sticky and slightly plastic when wet, very friable dry, common woody and fibrous roots, clear smooth boundary. 16% Clay, CEC = 6.6 cmol/kg clay, BSP = 15.8%, TOC = 0.9%
	15 - 50 cm. E/B Light brown (5YR 5/8), moist fine sandy loam, few medium distinct dark yellowish brown (10YR 4/2) mottles, no stones, common very fine steel grey nodules (ferro-manganese), gradual smooth boundary. 27% Clay, CEC = 11.1 cmol/kg clay, BSP = 11.3%
	50 - 130 cm. Bs Dark yellowish orange (10YR 6/6), dry sandy loam, moderate granular structure, friable when moist, slightly sticky and slightly plastic when wet, slightly hard when dry, many distinct strong brown (5YR 4/6), medium iron oxide nodules. 35% Clay, CEC = 29 cmol/kg clay, BSP = 14.1%

Profile No.	**Chim/SPP-04**
Soil Classification	**Gleyic Dystric Cambisol (FAO-IRIC-ISSS, 1998)**
Location	Approximately 100 metres south of Chimiwungo Stream in the Chimiwungo dambo. Northwestern Province of Zambia.
Grid Reference	UTM 35L co-ordinates 377685E 8642162N
Described by	Mattias Fackel.
Date	21 November 2001.
Elevation	Approximately 1300 O.D.
Relief	Bottom of gentle slope approximately 4 kilometres from slope crest. Dome structure surrounded by gently undulating plateau.
Slope	5 degrees.
Aspect	330°NNE
Parent Material	Basement schist. Lower Roan and undifferentiated Basement Complex.
Soil Surface	Uneven terrain, 15 cm high tussocks of grass.
Erosion/Deposition	None.
Rock Outcrops	None.
Land Use	None.
Vegetation	Sedges and grasses.
Soil Horizons CEC = Cation Exchange Capacity BSP = Base Saturation Percentage TOC = Total Organic Carbon Percentage in 'A' Horizon	0 - 10 cm. Ah Black (5YR 2.5/1), moist silt, weak medium crumb structure, friable when moist, slightly sticky and slightly plastic when wet, >5% porosity, many fine to medium roots, termites and termite burrows, smooth gradual boundary. 28% Clay, CEC = 47 cmol/kg clay, BSP = 12.2%, TOC = 6.2%
	10 - 35 cm. Bg Dark grey (5YR 4/1), moist silt, firm when moist, slightly sticky and slightly plastic when wet, termites and termite burrows, smooth gradual boundary. 32% Clay, CEC = 15 cmol/kg clay, BSP = 11.1%
	35 - 50 cm. Bg Brownish grey (5YR 4/1), sandy clay loam, apedal, firm when moist, moderately sticky and moderately plastic when wet, 0.5% fine pores, with sand lenses, few medium roots, termites and termite burrows, water table at 50 cm depth. 26% Clay, CEC = 11 cmol/kg clay, BSP = 11.6%

Profile No.	**Chim/SPP-05**
Soil Classification	**Geric Acrisol (FAO-IRIC-ISSS, 1998)**
Location	Approximately 200 metres north of Chimiwungo Copper Deposit in the Northwestern Province of Zambia.
Grid Reference	UTM 35L co-ordinates 378011E 8642401N
Described by	Mattias Fackel.
Date	11 December 2001.
Elevation	Approximately 1300 O.D.
Relief	Mid slope approximately 1.5 kilometres from slope crest on dome structure surrounded by gently undulating plateau.
Slope	<5 degrees.
Aspect	250°SW
Parent Material	Basement schist. Lower Roan and undifferentiated Basement Complex.
Soil Surface	Flat terrain.
Erosion/Deposition	None evident.
Rock Outcrops	None.
Land Use	None.
Vegetation	Wetter Zambezi Broadleaf/Miombo Woodland.
Soil Horizons CEC = Cation Exchange Capacity BSP = Base Saturation Percentage TOC = Total Organic Carbon Percentage in ‘A’ Horizon	0 - 10 cm. Ah Moderate brown (5YR 3/3), dry loamy sand, weak fine crumb structure, loose when dry, slightly sticky and slightly plastic when wet, >5% medium pores, common medium and coarse roots, clear smooth boundary. 18% Clay, CEC = 15 cmol/kg clay, BSP = 8.0%, TOC = 1.3%
	10 - 35 cm. B (10YR 4/6), moist sandy loam, coarse granular structure, firm when moist, slightly sticky and moderately plastic when wet, 0.5% fine pores, few medium roots, gradual smooth boundary. 19% Clay, CEC = 8.1cmol/kg clay, BSP = 10.6%
	35 - 140 cm. Bg Dark yellowish orange (10YR 6/6), moist silty clay loam, weak coarse granular structure, firm when moist, moderately sticky and moderately plastic when wet, few coarse woody roots. 39% Clay, CEC = 32 cmol/kg clay, BSP = 9.4%

Appendix P

Baseline Soil Geochemical Analysis

Geochemical Analysis of Soil Samples

Soil Pit No.	Soil Sample No.	Sampling Date	Sample Depth (cm)	Element Concentration in Soil (mg/kg)										
				Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe
SP-01	Mal/SP-01	24.Nov.01	0 - 15	4,200	2	49	23	<1	<1	<1	<1	2	10	8,200
SP-02	Mal/SP-02	24.Nov.01	0 - 15	6,800	2	64	19	<1	<1	<1	<1	7	100	19,200
SP-03	Mal/SP-03	26.Nov.01	0 - 15	4,600	2	58	16	<1	<1	<1	<1	<1	5	9,100
SP-04	Mal/SP-04	25.Nov.01	0 - 15	5,000	2	60	17	<1	<1	<1	<1	6	11	5,200
SP-05	Mal/SP-05	25.Nov.01	0 - 15	4,800	2	62	18	<1	<1	<1	<1	6	3	5,100
SP-06	Mal/SP-06	11.Dec.01	0 - 15	6,000	2	65	14	<1	<1	<1	<1	<1	7	6,800
SP-07	Mal/SP-07	26.Nov.01	0 - 15	9,600	2	67	28	<1	<1	<1	<1	<1	10	7,400
SP-08	Mal/SP-08	26.Nov.01	0 - 15	6,000	2	68	37	<1	<1	<1	<1	6	36	6,700

Soil Pit No.	Soil Sample No.	Sampling Date	Sample Depth (cm)	Element Concentration in Soil (mg/kg)										
				Hg	Mg	Mn	Mo	Ni	Pb	Se	V	Zn	U	
SP-01	Mal/SP-01	24.Nov.01	0 - 15	<1	298	11	<1	<1	4	<1	<1	2	2	
SP-02	Mal/SP-02	24.Nov.01	0 - 15	<1	270	27	<1	<1	1	<1	<1	3	9	
SP-03	Mal/SP-03	26.Nov.01	0 - 15	<1	156	28	<1	<1	<1	<1	<1	2	19	
SP-04	Mal/SP-04	25.Nov.01	0 - 15	<1	53	42	<1	<1	1	<1	<1	2	21	
SP-05	Mal/SP-05	25.Nov.01	0 - 15	<1	37	11	<1	<1	<1	<1	<1	3	<1	
SP-06	Mal/SP-06	11.Dec.01	0 - 15	<1	437	28	<1	6	<1	<1	<1	2	27	
SP-07	Mal/SP-07	26.Nov.01	0 - 15	<1	67	65	<1	<1	<1	<1	<1	3	11	
SP-08	Mal/SP-08	26.Nov.01	0 - 15	<1	33	8	<1	<1	<1	<1	<1	2	8	

Appendix Q

Participatory Rural Assessment

<table>
<tr><td>Date: 27th January 2002</td><td>Venue: Chief Mukumbi's Palace</td><td>Meeting: 1</td></tr>
<tr><td colspan="2">Present:
Chief Mukumbi
Kizeza Kapumba (Chief Retainer)
Pellama Muluka Mukumbi (Mukumbi Ward Councillor)
Fred Muluka (Chief's son)</td><td>Facilitators/Interviewers:
Mitulo Silengo
Nyundo Armitage</td></tr>
<tr><td colspan="3">Purpose of meeting: To meet Chief Mukumbi and discuss traditional governance and development in the chiefdom</td></tr>
</table>

Issues raised:

- Traditional governance in Chief Mukumbi - Chief superintends over matters affecting people in his chiefdom assisted by village Headmen and Deputy Headmen.
- The Chief has been on the throne since 1962.
  Chief attends to traditional (tribal matters) as well as development issues in his chiefdom.
- Councillors represent formal local governmental structures.
  Local courts represent the formal legislative structure presided over by court assessor appointed with recommendation of the Chief.
- Kufukwila Ceremony observed in mid-May to thank God and ancestors for the land and harvest.
- Traditional sites include a shrine near the Chief's palace used for ceremonies.
- Subsistence agriculture is the mainstay of the people in the area growing beans, maize, millet, sorghum, cassava, sweet potatoes and pineapples.
- Social infrastructure - there are 8 rural health centres, 12 schools and 5 agricultural camps.
- The Flying Doctor Service used to make weekly visits landing at an airstrip in Mukumbi North.
- Malaria is the number 1 disease affecting the population in the area.
- A campaign to combat malaria was launched in the villages through use of impregnated nets.
- Water supply is from wells and springs near rivers and streams.
- A company called Giacomine owned by group of Italians operates Kafilondo Mine, a facing stone quarry mining a nepheline syenite plug in the Northwest of Chief Mukumbi's area but only employs about 8 persons. Blocks of stone are exported to foreign markets.
- Local people are expectant that EQCV will develop the Lumwana copper deposits and thus create jobs for people in Mukumbi's area, and also for the province and nation as a whole.
- It is expected that non-skilled mine jobs will be undertaken by the local people.
- There are currently no problems with people from the Meheba Camp who are very productive.
- Security at the DRC border posts may need to be augmented when the mine opens.

Date: 28th January 2002	**Venue**: Manyama School	**Meeting**: 2

Present: Chief Mukumbi (See attached list of 145 attendees)	**Facilitators:** Mitulo Silengo Nyundo Armitage

Purpose of community meeting: To obtain information about communities in the Lumwana East area of Chief Mukumbi chiefdom.

Issues raised:

Social fabric and structure:

- This is based on the family unit, which is the basis of a village. Personal identity of the family unit is important in defining village entity.

- The Chief has overall traditional authority with next level of traditional authority held by *ba Kitumbafumo* (Group Leaders) and then *ba Mwinamuzi* (Village Headmen).

- Communities play a part in the appointment of traditional leaders by recommending those to be appointed to the Chief.

- The main tribes in Chief Mukumbi's area are Kaonde, Lunda, Luvale, Chokwe and to a lesser extent Bemba.

- The main language spoken is Kaonde. Lunda is also used.

- Inter-marriages across tribal lines are common and people live together in harmony.

- *Kufukwila* is an important cultural ceremonial event held in May.

Livelihoods and incomes:

- Farming is the main source of livelihood. *Masala* (slash-and-burn) is practised. Both men and women are involved in this activity.
- Crops grown include maize, millet, sorghum, cassava, sweet potatoes, beans and pineapples.
- People are concerned about the possible loss of farmland in the future mine licence area.
- Livestock keeping is also practised, the main animals being goats, pigs, sheep and chickens. Cattle are also reared but are less common.

Other activities include:

- Beekeeping, woodcarving, craft making and basket weaving.
- Beer brewing is mainly an occupation undertaken by women. *Kasonge* is brewed by fermenting maize, millet or sorghum. *Munkoyo* a non-alcoholic beverage is also made. *Mbote* (gin made from fermenting honey) gin-making is normally undertaken by men because of the risk of bee stings.

- Trading is undertaken by a few. Second-hand clothes bought at the DRC border are sold or bartered for maize.
- Small shops selling groceries are found along the main road normally run by men.
- Blacksmithing.
- Fishing.
- Charcoal burning.

Institutions

- Traditional institutions are a permanent feature.
- Political institutions are present. All political parties were represented during the 2001 tripartite elections. The main political parties represented in the area are UPND and MMD.
- Chief Mukumbi's area falls under Solwezi West Constituency. It has 2 Wards represented by UPND Councillors.
- The Church is an important institution in the lives of people. Various denominations are found in the area including:
  - United Methodist Church
  - Evangelical Church of Zambia
  - Roman Catholic Church
  - Open Church
  - Christian Community Church
  - Christian Missions in Many Lands
  - New Apostolic Church
  - New Covenant Church
  - Baptist
  - Seventh Day Adventist Church
  - Jehovah's' Witness
  - Pentecostal Assemblies of God
  - Jordan Church

- Women' Clubs include: Lusalwalesa Women's Club and Ukwasho Women's Club. These are involved in sewing and knitting. Products are sold for cash or bartered for maize.
- Other institutions, which have worked in the area, include IFAD (constructing a school), ZAMSIF (constructing a school), Department of Water Affairs (sinking wells).

Social Infrastructure

- This includes school and rural health centres.
- Government runs schools, which include Primary, Basic and Middle Basic Schools.
- Government runs rural health centres and the Holy Family Catholic Church runs one.
- The Catholic Church Primary Health Services provides complimentary services for under-five clinics, ante-natal clinics and home-based care (Sr. Franscisca Mutole).
- There are 7 rural health centres (Mangala Rural Health Centre, Kyanika Rural Health Centre, Mumbhezi ZNS Rural Health Centre, Mukumbi Rural Health Centre, Lumwana Rural Health Centre, Holy Family Rural Health Centre and Kalengelenge Rural Health Centre).
- Water is provided from wells and streams.

PRA Community Meeting Attendance Register

	Date: 28 January 2002	**Venue: Manyama School**
	Facilitators: Mitulo Silengo Nyundo Armitage	
	Attendee:	**Village**
1	Chief Mukumbi Ibaloli	Mukumbi palace
2	Mr. C. Musonda (Headmaster)	Manyama School
3	Mr. E. Kaponda (Teacher)	Manyama School
4	Mr. Kapitolo (senior Teacher)	Manyama School
5	Mr. S. Kalenga (Headman)	Mwajimulemba
6	Mr. A. Lukama (Headman)	Zengamina
7	Mr. R. Kamwana (Headman)	Kamwana
8	Mr. Ingomi Weseka (Headman)	Weseka
9	Mr. Nchoka (Headman)	Nchoka
10	Mr. P. Chiteta (Headman)	Chiteta
11	Mr. K. Kahumuna (Headman)	Kahumuna
12	Mr. K. Samakayi	Chiteta
13	Mr. K. Mbimbi (Headman)	Mbimbi
14	Mr. A. Sakanya (Headman)	Sakanya
15	Mr. E. Bulaya	Muke
16	Mr. Muzhama (Headman)	Muzhama
17	Mr. M. Kitamfya (Group Leader)	Mafuta
18	Mr. P. Machaya (Headman)	Machaya
19	Mr. B. M. Mangi	Chiteta
20	Mr. W. Kahumuna (Headman)	Kahumuna
21	Mr. B. Malichi	Chiteta
22	Mr. G. Sakuwaha (Headman)	Sakuwaha
23	Mr. J. Kasongo	Kalwila
24	Mr. M. Kandasa	Muke
25	Mr. C. Sipanyela	Sipanyela
26	Mr. A. Nkumba (Headman)	Nkumba
27	Mr. M. Mutantabobwa (Headman)	Lewila
28	Mr. J. Samulozanga (Headman)	Muhangu
29	Mr. R. Mulopu (Headman)	Mulopu
30	Mr. J. S. Kuluza (Headman)	Kuluza
31	Mr. S. Sandu (Headman)	Sandu
32	Mr. S. Matunka (Headman)	Matunka
33	Mr. I. Mushipi (Headman)	Mushipi
34	Mr. N. Maliki (Headman)	Maliki
35	Mr. L. Wishikoti	Loti
36	Mr. M. Kasongo (Headman)	Makondo
37	Mr. W. Kondowe	Kiwala
38	Mr. K. Kahumuna	Kahumuna
39	Mrs. Y. Paya	Kakompe
40	Mrs. T. Mukwemba	Kakompe
41	Mrs. L. Chimwanga	Kakoma
42	Mrs. S. Matunka	Matunka
43	Mrs. C. Kankinza	Chiyanga
44	Mrs. Musonda	Manyama School
45	Mrs. F. Kakoma	Kakoma

46	Mrs. A. Lusambo	Lusambo
47	Mrs. H. Kamalondo	Kayamba
48	Mrs. G. Mutonyo	Kakompe
49	Mrs. M. Muzhama	Muzhama
50	Miss J. Yengwe	Kilanzhi
51	Miss N. Sandala	Kachaka
52	Miss S. Masenyenge	Kaumba
53	Mrs. M. Kapitolo	Manyama School
54	Miss D. Kilondo	Kakompe
57	Mrs. S. Ngwezhi	Kayumba
55	Magie Mumba	Mumba
56	Miss A. Mumba	Mumba
58	Miss R. Mphenzi	Mphenzi
59	Mrs. Y. Kyabe	Kiwala
60	Mrs. L. Katontoka	Lupese
61	Miss F. Mukosahi	Samulozanga
62	Mrs. N. Mukanda	Mukanda
63	Mrs. P. Kachunga	Kachunga
64	Miss C. Belena	Kasongo
65	Miss I. Kalibuku	Kasongo
66	Mrs. E. Kaloza	Kasongo
67	Mrs. Y. Mandona	Mandona
68	Miss J. Kakoma	Muleyi
69	Miss B. Muhongo	Mwanza
70	Mrs. I. Ngwezhi	Kayumba
71	Mrs. Kyomba	Kakompe
72	Mrs. M. Mwalimu	Jifumpa
73	Miss D. Muzhama	Muzhama
74	Miss S. Kalusa	Chikasa
75	Mrs. Kanyungilo	Lusambo
76	Mrs. M. Mukimbi	Masumba
77	Mrs. B. Mutonyi	Kakompe
78	Mr. D. Mako	Kahumuna
79	Mr. J. Katutisa	Kahumuna
80	Mr. M. Kipenda	Poolo
81	Mr. C. Chikomena	Chikomena
82	Mr. S. Mwanza	Muzhina
83	Mr. R. Nawezhi	Makondo
84	A. Mukosayi	Samulozanga
85	F. Chinyingi	Samulozanga
86	Mr. D. Musonda	Musonda
87	Mr. J. Mulengi	Sheyama
88	Tobias Mutumbo	Ntakaila
89	Mr. J. Kapobe	Kapobe
90	Mr. N. Kasujami	Kakompe
91	J Kajimanga	Kajimanga
92	Mr. A. Mokola	Mokola
93	Mr. B. Kadansa	Muke
94	Mr. R. Musonda	Musonda
95	Mr. W. Amos	Muzhina
96	Mr. T. Mumba	Masheka

97	Mr. G. Matafwali	Kadima
98	Mr. J. Katolu	Katolu
99	Mr. J. Kamalondo	Kayamba
100	Mr. M. Katenga	Katenga
101	Mr. A. Sakanya	Sakanya
102	Mr. A. Kitamfya	Mafuta
103	Mr. J. Kamalamba	Nyamuyamba
104	Mr. J. Samukoko	Malembeka
105	Mr. E. Kayumba	Kayumba
106	Mr. T. Kalala	Maliki
107	Mr. V. Chinyingi	Samulozanga
108	Mr. A. Kalwizhi	Samulozanga
109	Mr. O. Chikomena	Chikomena
110	Lewis Mphenzhi	Mpenzhi
111	D. Kadochi	Mpenzhi
112	K. Oberty	Manyama School
113	M. Bushengwe	Bushengwe
114	Mr. G. Matoka	Makondo
115	Mr. G. Mutombo	Sheyama
116	Mr. E. Mukanda	Mukanda
117	Mr. J Kyanyika	Mudemba
118	Mr. K. Kabendwe	Kabendwe
119	Mr. J. Mukanzu	Kabuka
120	B. Medala	Medala
121	Mr. S. Katolongo	Kumba
122	Mr. M. Mwaba	Mandona
123	Mr. L. Sendwe	Mandona
124	Mr. B. Monde	Mandona
125	Mr. R. Masenyenge	Kipenda
126	Mr. L. Mutatabowa	Mutatabowa
127	Mr. L. Kasunami	Mudemba
128	Mr. B. Shindano	Lubese
129	Mr. J. Kapemba	Kapemba
130	Mr. G. Alube	Masuwa
131	Mr. Y. Kizhoka	Yamwa
132	Mr. M. C. Makungu	Makungu
133	Mr. D. Matanta	Lulenga
134	Mr. L. Petimoya	Petimoya
135	Mr. Kangungu	Muleyi
136	Mr. K. Pemba	Kayumba
137	Mr. F. Mwamba	Kayuka
138	Mr. D. Majinde	Mulopwe
139	Mr. A. Mabimba	C.C.C
140	Mr. F. Sakuwaha	C.C.C
141	Mr. H. Mulenga	Sumbula
142	Mr. M. Power	Lewile
143	Mr. J. Chiputa	Chiputa
144	Mr. D. Kaumba	Kasongo
145	Mr. Katatala	Subula

List of key informants / interviewees

1. Chief Mukumbi Ibaloli
2. Mr. Ng'andu - Senior Education Planning Officer, Northwestern Province
3. Mr. Nuwa Senkebe - Refugee Project Coordinator, The Lutheran World Federation, Meheba
4. Mr. Enock Kalombo - Central Board of Health, Provincial Clinical Care Specialist, Solwezi
5. Ms Bupe Kanyense - Teacher, Lumwana East Upper Basic School, Solwezi
6. Mrs. Violet Ndakala - Nurse, Lumwana East Rural Health Centre
7. Sr. Franscisca Mutole - Nurse, Holy Family Rural Health Centre
8. Mr. Godfrey Hazuza - Health Inspector, Solwezi District Health Management Team
9. Mr. Edwin Samu - Environmental Health Technician, Solwezi District Health Management Team
10. Mr. Emmanuel Egyir - UNCHR Protection Officer, Solwezi
11. Mr. Moses Kasongo - ZAMSIF Technical Adviser, Manyama School
12. Mr. Elias Wishikoti Katambi (Former Commissioner of Police/Diplomat), Katambi Village, Solwezi
13. Mr. C. Musonda - Headmaster, Manyama School, Solwezi
14. Mrs. M. Lweleya, UNCHR, Lusaka

Appendix R

T5 Regional Traffic Survey, September 2002
Raw Data

Road Traffic Survey, September 2002 - T5 Main Road (Mutanda Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
02-Sep-02	06.00-07.00	IN	2	3	0	0	0	0	0	0	0
		OUT	3	2	0	0	2	0	0	0	0
02-Sep-02	07.00-08.00	IN	51	5	1	0	0	0	0	0	0
		OUT	10	5	0	0	0	0	0	0	0
02-Sep-02	08-00-09.00	IN	59	5	0	0	0	0	0	0	0
		OUT	24	10	0	0	1	1	1	0	0
02-Sep-02	09.00-10.00	IN	23	9	0	0	0	0	0	0	0
		OUT	27	11	0	0	3	3	0	0	0
02-Sep-02	10.00-11.00	IN	14	5	0	0	3	0	0	1	0
		OUT	30	6	0	0	1	0	1	0	0
02-Sep-02	11.00-12.00	IN	9	8	0	0	2	0	4	0	0
		OUT	9	7	0	0	2	0	2	2	0
02-Sep-02	12.00-13.00	IN	19	2	0	1	5	0	0	0	0
		OUT	8	5	0	0	0	1	0	0	0
02-Sep-02	13.00-14.00	IN	8	9	0	0	2	0	0	0	1
		OUT	18	2	0	0	2	0	2	0	0
02-Sep-02	14.00-15.00	IN	4	10	1	0	0	4	1	1	0
		OUT	21	0	0	0	1	0	0	0	0
02-Sep-02	15.00-16.00	IN	15	8	0	0	1	2	0	0	0
		OUT	14	9	0	0	0	0	0	0	0
02-Sep-02	16.00-17.00	IN	67	12	0	0	3	0	1	0	0
		OUT	18	7	0	0	1	0	2	0	0
02-Sep-02	17.00-18.00	IN	26	15	0	0	2	0	2	0	0
		OUT	13	2	0	0	1	0	1	0	0
		Totals: (IN)	297	91	2	1	18	6	8	2	1
		Totals: (OUT)	195	66	0	0	14	5	9	2	0

Road Traffic Survey, September 2002 – T5 Main Road (Mutanda Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
03-Sep-02	06.00-07.00	IN	4	4	0	0	1	0	0	0	1
		OUT	3	5	0	0	0	0	0	0	0
03-Sep-02	07.00-08.00	IN	0	7	0	0	0	0	1	1	0
		OUT	7	6	0	0	2	0	0	0	0
03-Sep-02	08-00-09.00	IN	10	9	0	0	0	1	0	0	0
		OUT	33	10	0	0	0	1	1	0	0
03-Sep-02	09.00-10.00	IN	23	7	0	0	3	1	0	0	0
		OUT	50	12	0	0	2	3	0	0	0
03-Sep-02	10.00-11.00	IN	14	5	0	1	0	0	0	0	1
		OUT	21	4	0	0	2	1	0	0	0
03-Sep-02	11.00-12.00	IN	18	10	0	0	0	1	0	0	0
		OUT	11	3	0	0	4	0	0	0	0
03-Sep-02	12.00-13.00	IN	6	6	0	1	1	0	0	0	0
		OUT	9	4	0	0	0	1	0	0	0
03-Sep-02	13.00-14.00	IN	17	4	0	2	0	0	0	0	0
		OUT	12	5	0	0	1	0	0	0	2
03-Sep-02	14.00-15.00	IN	8	2	0	0	1	0	0	0	0
		OUT	5	3	0	1	2	0	2	1	0
03-Sep-02	15.00-16.00	IN	14	2	1	0	0	0	1	1	0
		OUT	18	2	0	0	3	0	1	1	0
03-Sep-02	16.00-17.00	IN	21	4	1	1	1	0	0	0	0
		OUT	12	8	0	1	3	0	0	0	0
03-Sep-02	17.00-18.00	IN	13	11	0	0	2	0	0	0	0
		OUT	17	4	0	1	3	0	1	0	0
		Totals: (IN)	**148**	**71**	**2**	**5**	**9**	**3**	**2**	**2**	**2**
		Totals: (OUT)	**198**	**66**	**0**	**3**	**22**	**6**	**5**	**2**	**2**

Road Traffic Survey, September 2002 - T5 Main Road (Mutanda Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
04-Sep-02	06.00-07.00	IN	2	2	0	0	0	0	0	0	0
		OUT	7	8	0	0	2	0	1	0	0
04-Sep-02	07.00-08.00	IN	7	2	0	0	0	0	1	0	0
		OUT	19	6	0	0	0	2	2	0	0
04-Sep-02	08-00-09.00	IN	3	3	1	0	1	0	1	0	0
		OUT	41	15	1	1	2	0	0	1	0
04-Sep-02	09.00-10.00	IN	27	5	0	0	0	0	0	0	0
		OUT	46	4	0	0	1	0	1	0	1
04-Sep-02	10.00-11.00	IN	15	5	0	1	2	0	0	0	0
		OUT	15	4	0	3	1	1	0	0	1
04-Sep-02	11.00-12.00	IN	17	3	0	0	3	0	0	0	0
		OUT	13	2	0	0	0	2	0	0	0
04-Sep-02	12.00-13.00	IN	21	7	0	0	3	0	3	1	0
		OUT	11	5	0	0	0	2	2	1	0
04-Sep-02	13.00-14.00	IN	18	2	0	0	1	0	1	0	0
		OUT	6	9	0	0	1	0	4	0	0
04-Sep-02	14.00-15.00	IN	14	5	0	0	2	1	2	0	0
		OUT	15	3	1	1	0	0	0	0	0
04-Sep-02	15.00-16.00	IN	27	13	0	0	2	0	0	0	0
		OUT	9	5	0	0	2	2	0	0	1
04-Sep-02	16.00-17.00	IN	4	8	0	0	2	0	1	0	0
		OUT	17	5	0	0	3	1	1	1	0
04-Sep-02	17.00-18.00	IN	12	3	0	0	5	0	2	0	0
		OUT	6	2	1	2	1	2	2	1	0
		Totals: (IN)	**167**	**58**	**1**	**1**	**21**	**1**	**11**	**1**	**0**
		Totals: (OUT)	**205**	**68**	**3**	**7**	**13**	**12**	**13**	**4**	**3**

Road Traffic Survey, September 2002 - T5 Main Road (Mutanda Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
05-Sep-02	06.00-07.00	IN	4	1	0	0	0	0	0	0	0
		OUT	15	3	0	0	5	0	0	0	0
05-Sep-02	07.00-08.00	IN	2	1	0	0	0	0	1	0	0
		OUT	16	11	0	0	1	1	0	0	0
05-Sep-02	08-00-09.00	IN	7	4	0	0	4	0	0	0	1
		OUT	27	17	0	2	0	0	1	0	1
05-Sep-02	09.00-10.00	IN	15	10	0	1	4	0	0	0	0
		OUT	25	7	0	1	4	2	2	0	0
05-Sep-02	10.00-11.00	IN	26	5	0	1	0	0	1	0	0
		OUT	14	8	1	0	2	0	4	1	2
05-Sep-02	11.00-12.00	IN	11	2	0	1	0	0	0	0	0
		OUT	10	5	0	0	1	0	0	0	0
05-Sep-02	12.00-13.00	IN	9	9	0	2	0	1	2	0	0
		OUT	15	5	0	1	0	2	1	0	0
05-Sep-02	13.00-14.00	IN	6	5	0	0	1	0	4	0	0
		OUT	17	3	1	0	0	0	1	0	0
05-Sep-02	14.00-15.00	IN	3	3	0	0	1	0	1	0	0
		OUT	19	2	0	0	2	0	3	0	1
05-Sep-02	15.00-16.00	IN	14	6	0	0	1	1	1	0	0
		OUT	19	6	0	2	3	2	2	2	0
05-Sep-02	16.00-17.00	IN	12	6	0	0	1	0	1	0	0
		OUT	17	4	0	1	0	1	0	1	0
05-Sep-02	17.00-18.00	IN	19	8	0	0	2	0	1	0	1
		OUT	28	1	0	3	3	2	4	1	0
		Totals: (IN)	**128**	**60**	**0**	**5**	**14**	**2**	**12**	**0**	**2**
		Totals: (OUT)	**222**	**72**	**2**	**10**	**21**	**10**	**18**	**5**	**4**

Road Traffic Survey, September 2002 - T5 Main Road (Mutanda Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
06-Sep-02	06.00-07.00	IN	1	1	0	0	0	0	2	1	0
		OUT	1	8	0	0	0	0	1	0	0
06-Sep-02	07.00-08.00	IN	9	7	0	0	1	0	1	0	0
		OUT	10	4	0	0	0	0	0	0	0
06-Sep-02	08-00-09.00	IN	6	3	0	0	1	0	1	0	0
		OUT	26	6	0	0	2	0	0	0	0
06-Sep-02	09.00-10.00	IN	15	4	0	0	2	0	1	1	0
		OUT	42	4	0	0	2	2	2	0	0
06-Sep-02	10.00-11.00	IN	26	2	0	0	0	1	1	0	0
		OUT	30	9	0	0	2	0	4	0	0
06-Sep-02	11.00-12.00	IN	18	5	0	1	0	0	1	0	0
		OUT	20	0	0	0	1	1	0	0	0
06-Sep-02	12.00-13.00	IN	12	7	0	1	7	0	0	0	1
		OUT	20	7	0	1	2	1	0	0	0
06-Sep-02	13.00-14.00	IN	17	9	0	3	4	2	1	1	1
		OUT	9	5	0	0	4	0	0	1	1
06-Sep-02	14.00-15.00	IN	11	1	0	0	3	0	0	0	0
		OUT	9	3	0	1	3	0	0	0	0
06-Sep-02	15.00-16.00	IN	9	4	0	0	2	0	0	0	0
		OUT	16	0	0	0	1	0	0	0	0
06-Sep-02	16.00-17.00	IN	11	4	0	0	0	0	0	1	0
		OUT	47	7	1	0	7	0	0	0	0
06-Sep-02	17.00-18.00	IN	26	6	0	0	2	1	0	0	0
		OUT	39	10	0	1	5	0	1	0	0
		Totals: (IN)	**161**	**53**	**0**	**5**	**22**	**4**	**8**	**4**	**2**
		Totals: (OUT)	269	63	1	3	29	4	8	1	1

Road Traffic Survey, September 2002 - T5 Main Road (Mutanda Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
07-Sep-02	06.00-07.00	IN	6	3	1	2	3	2	4	1	0
		OUT	7	3	0	0	1	0	0	0	0
07-Sep-02	07.00-08.00	IN	13	0	0	0	1	0	1	0	0
		OUT	16	8	0	0	3	0	0	0	0
07-Sep-02	08-00-09.00	IN	8	4	0	0	4	1	0	0	0
		OUT	14	5	0	1	1	0	4	0	0
07-Sep-02	09.00-10.00	IN	14	7	0	0	2	2	1	0	0
		OUT	29	10	0	1	4	3	0	0	0
07-Sep-02	10.00-11.00	IN	5	7	1	3	3	2	0	0	1
		OUT	22	7	0	0	5	1	5	0	0
07-Sep-02	11.00-12.00	IN	7	7	0	0	6	1	2	3	0
		OUT	30	19	0	5	11	2	7	2	0
07-Sep-02	12.00-13.00	IN	12	4	1	0	3	1	0	0	0
		OUT	4	1	0	0	0	1	1	0	0
07-Sep-02	13.00-14.00	IN	11	1	0	0	3	0	1	0	1
		OUT	15	3	0	0	3	0	3	0	0
07-Sep-02	14.00-15.00	IN	13	3	0	0	3	0	0	0	0
		OUT	14	1	0	0	2	0	0	0	0
07-Sep-02	15.00-16.00	IN	12	3	0	0	1	1	0	0	0
		OUT	15	7	0	0	2	2	0	0	0
07-Sep-02	16.00-17.00	IN	14	10	0	0	0	0	0	0	0
		OUT	27	8	0	5	8	2	4	1	0
07-Sep-02	17.00-18.00	IN	7	0	0	0	1	0	0	0	0
		OUT	25	8	0	0	4	1	3	0	0
		Totals: (IN)	122	49	3	5	30	10	9	4	2
		Totals: (OUT)	218	80	0	12	44	12	27	3	0

Road Traffic Survey, September 2002 - T5 Main Road (Mutanda Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
08-Sep-02	06.00-07.00	IN	6	3	1	2	3	2	4	1	0
		OUT	7	3	0	0	1	0	0	0	0
08-Sep-02	07.00-08.00	IN	13	0	0	0	1	0	1	0	0
		OUT	16	8	0	0	3	0	0	0	0
08-Sep-02	08-00-09.00	IN	8	4	0	0	4	1	0	0	0
		OUT	14	5	0	1	1	0	4	0	0
08-Sep-02	09.00-10.00	IN	14	7	0	0	2	2	1	0	0
		OUT	29	10	0	1	4	3	0	0	0
08-Sep-02	10.00-11.00	IN	5	7	1	3	3	2	0	0	1
		OUT	22	7	0	0	5	1	5	0	0
08-Sep-02	11.00-12.00	IN	7	7	0	0	6	1	2	3	0
		OUT	30	19	0	5	11	2	7	2	0
08-Sep-02	12.00-13.00	IN	12	4	1	0	3	1	0	0	0
		OUT	4	1	0	0	0	1	1	0	0
08-Sep-02	13.00-14.00	IN	11	1	0	0	3	0	1	0	1
		OUT	15	3	0	0	3	0	3	0	0
08-Sep-02	14.00-15.00	IN	13	3	0	0	3	0	0	0	0
		OUT	14	1	0	0	2	0	0	0	0
08-Sep-02	15.00-16.00	IN	12	3	0	0	1	1	0	0	0
		OUT	15	7	0	0	2	2	0	0	0
08-Sep-02	16.00-17.00	IN	14	10	0	0	0	0	0	0	0
		OUT	27	8	0	5	8	2	4	1	0
08-Sep-02	17.00-18.00	IN	7	0	0	0	1	0	0	0	0
		OUT	25	8	0	0	4	1	3	0	0
		Totals: (IN)	122	49	3	5	30	10	9	4	2
		Totals: (OUT)	218	80	0	12	44	12	27	3	0

Road Traffic Survey, September 2002 - T5 Main Road (Muchinshi)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
02-Sep-02	06.00-07.00	IN	9	7	0	0	0	0	0	0	0
		OUT	7	6	0	0	0	0	1	0	0
02-Sep-02	07.00-08.00	IN	21	9	0	0	0	0	1	0	0
		OUT	3	6	0	2	1	0	1	0	0
02-Sep-02	08-00-09.00	IN	25	10	0	0	0	0	1	0	0
		OUT	15	12	0	5	0	2	0	1	0
02-Sep-02	09.00-10.00	IN	19	18	0	0	1	0	2	0	0
		OUT	9	11	0	1	0	0	0	0	0
02-Sep-02	10.00-11.00	IN	14	11	0	1	1	1	1	1	0
		OUT	8	9	0	0	2	1	2	0	0
02-Sep-02	11.00-12.00	IN	16	9	0	1	1	0	1	0	0
		OUT	27	8	0	0	5	0	2	0	0
02-Sep-02	12.00-13.00	IN	4	6	0	1	3	1	4	1	0
		OUT	22	7	0	1	2	2	1	0	0
02-Sep-02	13.00-14.00	IN	8	8	0	0	2	2	4	0	0
		OUT	6	5	0	0	4	1	1	2	0
02-Sep-02	14.00-15.00	IN	4	21	0	1	3	1	1	1	0
		OUT	9	5	0	0	5	1	1	0	0
02-Sep-02	15.00-16.00	IN	26	11	0	0	1	1	3	0	0
		OUT	10	7	0	0	2	1	2	0	0
02-Sep-02	16.00-17.00	IN	19	16	0	1	1	0	1	0	0
		OUT	9	13	0	0	2	1	0	0	0
02-Sep-02	17.00-18.00	IN	12	7	0	1	1	0	1	1	0
		OUT	8	6	0	0	1	1	3	0	0

	Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
Totals: (IN)	**177**	**133**	**0**	**6**	**14**	**6**	**20**	**4**	**0**
Totals: (OUT)	133	95	0	9	24	10	14	3	0

Road Traffic Survey, September 2002 - T5 Main Road (Muchinshi)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
03-Sep-02	06.00-07.00	IN	8	7	0	0	2	0	0	0	0
		OUT	4	4	0	0	0	0	0	0	0
03-Sep-02	07.00-08.00	IN	13	4	0	0	1	0	0	0	0
		OUT	4	5	0	0	0	0	1	1	0
03-Sep-02	08-00-09.00	IN	26	17	0	0	4	0	1	0	0
		OUT	7	4	0	2	3	1	2	1	0
03-Sep-02	09.00-10.00	IN	12	18	0	0	0	0	4	0	0
		OUT	6	2	0	0	1	1	2	0	0
03-Sep-02	10.00-11.00	IN	16	10	0	2	2	1	1	1	0
		OUT	17	5	0	1	3	0	1	0	0
03-Sep-02	11.00-12.00	IN	17	15	0	4	4	1	1	1	0
		OUT	16	15	0	1	1	0	3	0	0
03-Sep-02	12.00-13.00	IN	15	14	0	1	4	1	1	0	0
		OUT	23	11	0	0	1	1	1	0	0
03-Sep-02	13.00-14.00	IN	4	8	0	2	4	0	4	1	0
		OUT	22	7	0	0	2	0	1	0	0
03-Sep-02	14.00-15.00	IN	7	12	0	0	2	2	5	0	0
		OUT	17	12	0	3	2	1	2	0	0
03-Sep-02	15.00-16.00	IN	14	16	0	0	5	1	3	0	0
		OUT	20	7	0	3	0	1	1	0	0
03-Sep-02	16.00-17.00	IN	24	11	0	0	2	1	1	0	0
		OUT	14	8	0	0	1	2	3	0	0
03-Sep-02	17.00-18.00	IN	23	17	0	2	5	0	2	0	0
		OUT	17	10	0	2	3	1	2	0	0
		Totals: (IN)	**179**	**149**	**0**	**11**	**35**	**7**	**23**	**3**	**0**
		Totals: (OUT)	**167**	**90**	**0**	**12**	**17**	**8**	**19**	**2**	**0**

Road Traffic Survey, September 2002 - T5 Main Road (Muchinshi)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
04-Sep-02	06.00-07.00	IN	7	4	0	0	1	0	0	0	0
		OUT	18	5	0	0	0	0	0	0	0
04-Sep-02	07.00-08.00	IN	13	5	0	0	0	0	1	0	0
		OUT	7	8	0	0	3	1	0	0	0
04-Sep-02	08-00-09.00	IN	18	16	0	0	5	0	3	0	0
		OUT	22	8	0	0	4	1	0	1	0
04-Sep-02	09.00-10.00	IN	32	16	0	0	4	0	0	0	0
		OUT	26	13	0	0	2	2	1	0	0
04-Sep-02	10.00-11.00	IN	33	12	0	0	3	1	6	1	0
		OUT	30	11	0	0	8	0	0	0	0
04-Sep-02	11.00-12.00	IN	13	5	0	0	1	1	4	0	0
		OUT	18	4	0	0	2	1	1	0	0
04-Sep-02	12.00-13.00	IN	9	3	0	0	3	0	2	0	0
		OUT	18	7	0	1	4	0	2	0	0
04-Sep-02	13.00-14.00	IN	7	9	0	1	2	0	2	2	0
		OUT	24	6	0	1	4	1	0	0	0
04-Sep-02	14.00-15.00	IN	15	7	0	1	6	2	0	0	0
		OUT	7	7	0	0	4	3	3	0	0
04-Sep-02	15.00-16.00	IN	26	16	0	0	4	1	2	0	0
		OUT	23	9	0	0	2	1	2	0	0
04-Sep-02	16.00-17.00	IN	18	15	0	0	3	1	2	0	0
		OUT	14	13	0	1	5	0	0	1	0
04-Sep-02	17.00-18.00	IN	10	14	0	0	3	0	1	0	0
		OUT	23	8	0	0	3	0	1	0	0
		Totals: (IN)	**201**	**122**	**0**	**2**	**35**	**6**	**23**	**3**	**0**
		Totals: (OUT)	**230**	**99**	**0**	**3**	**41**	**10**	**10**	**2**	**0**

Road Traffic Survey, September 2002 - T5 Main Road (Muchinshi)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
05-Sep-02	06.00-07.00	IN	12	0	0	0	1	0	0	0	0
		OUT	11	4	0	0	2	0	0	0	0
05-Sep-02	07.00-08.00	IN	5	5	0	0	2	0	3	0	0
		OUT	4	4	0	0	0	0	2	1	0
05-Sep-02	08-00-09.00	IN	11	16	0	0	5	0	2	0	0
		OUT	11	7	0	0	5	1	0	1	0
05-Sep-02	09.00-10.00	IN	19	13	0	1	1	0	2	0	0
		OUT	21	6	0	0	4	1	2	0	0
05-Sep-02	10.00-11.00	IN	15	3	0	1	3	1	4	0	0
		OUT	20	3	0	0	4	0	3	0	0
05-Sep-02	11.00-12.00	IN	15	10	0	0	3	2	4	0	0
		OUT	18	8	0	1	0	0	0	0	0
05-Sep-02	12.00-13.00	IN	15	6	0	0	3	0	1	1	0
		OUT	20	8	0	1	2	0	2	0	0
05-Sep-02	13.00-14.00	IN	6	4	0	1	7	2	1	1	0
		OUT	26	8	0	1	2	1	0	0	0
05-Sep-02	14.00-15.00	IN	13	15	0	2	3	2	1	0	0
		OUT	6	3	0	1	4	1	1	1	0
05-Sep-02	15.00-16.00	IN	20	4	0	1	1	1	0	0	0
		OUT	36	12	0	2	5	1	2	0	0
05-Sep-02	16.00-17.00	IN	14	11	0	1	2	0	2	0	0
		OUT	16	10	0	0	4	0	2	0	0
05-Sep-02	17.00-18.00	IN	29	19	0	0	4	0	1	0	0
		OUT	31	7	0	0	5	0	0	0	0
		Totals: (IN)	174	106	0	7	35	8	21	2	0
		Totals: (OUT)	220	80	0	6	37	5	14	3	0

Road Traffic Survey, September 2002 - T5 Main Road (Muchinshi)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
06-Sep-02	06.00-07.00	IN	4	7	0	0	0	0	0	0	0
		OUT	11	4	0	0	0	0	0	0	0
06-Sep-02	07.00-08.00	IN	9	6	0	0	0	0	0	0	0
		OUT	6	4	0	0	3	0	0	0	0
06-Sep-02	08-00-09.00	IN	9	8	0	0	2	0	2	0	0
		OUT	20	6	0	0	8	1	2	1	0
06-Sep-02	09.00-10.00	IN	12	13	0	0	1	0	3	0	0
		OUT	16	8	0	1	1	0	0	0	0
06-Sep-02	10.00-11.00	IN	37	14	0	1	2	2	4	1	0
		OUT	27	6	0	0	2	0	0	0	0
06-Sep-02	11.00-12.00	IN	24	13	0	0	2	2	0	0	0
		OUT	28	11	0	0	3	1	1	0	0
06-Sep-02	12.00-13.00	IN	2	15	0	1	4	0	1	0	0
		OUT	37	10	0	0	0	2	2	0	0
06-Sep-02	13.00-14.00	IN	8	14	0	0	1	1	0	3	0
		OUT	12	8	0	2	2	0	2	0	0
06-Sep-02	14.00-15.00	IN	4	9	0	0	3	1	1	0	0
		OUT	13	13	0	3	1	0	0	0	0
06-Sep-02	15.00-16.00	IN	24	11	0	1	3	1	2	0	0
		OUT	21	10	0	0	2	3	1	0	0
06-Sep-02	16.00-17.00	IN	6	6	0	2	1	0	1	0	0
		OUT	21	13	0	2	2	0	1	0	0
06-Sep-02	17.00-18.00	IN	20	13	0	0	2	1	1	0	0
		OUT	27	6	0	0	4	0	0	0	0
		Totals: (IN)	159	129	0	5	21	8	15	4	0
		Totals: (OUT)	239	99	0	8	28	7	9	1	0

Road Traffic Survey, September 2002 - T5 Main Road (Muchinshi)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
07-Sep-02	06.00-07.00	IN	4	1	0	1	0	0	0	0	0
		OUT	12	5	0	0	2	0	0	0	0
07-Sep-02	07.00-08.00	IN	2	8	0	1	2	0	3	3	0
		OUT	5	4	0	0	2	0	0	0	0
07-Sep-02	08-00-09.00	IN	24	9	0	1	5	0	2	0	0
		OUT	8	8	0	1	5	1	2	1	0
07-Sep-02	09.00-10.00	IN	28	11	0	1	1	0	0	0	0
		OUT	12	9	0	0	6	0	2	0	0
07-Sep-02	10.00-11.00	IN	23	9	0	1	2	1	2	0	0
		OUT	25	5	0	0	2	2	2	0	0
07-Sep-02	11.00-12.00	IN	12	4	0	1	4	0	2	0	0
		OUT	20	4	0	0	2	1	1	0	0
07-Sep-02	12.00-13.00	IN	12	9	0	1	4	0	1	1	0
		OUT	27	12	0	0	4	0	1	0	0
07-Sep-02	13.00-14.00	IN	23	13	0	2	3	2	0	1	0
		OUT	14	11	0	2	1	0	2	0	0
07-Sep-02	14.00-15.00	IN	18	4	0	3	4	3	2	0	0
		OUT	20	9	0	1	2	1	5	1	0
07-Sep-02	15.00-16.00	IN	13	15	0	3	10	2	1	0	0
		OUT	24	14	0	1	4	2	3	0	0
07-Sep-02	16.00-17.00	IN	12	14	0	0	2	1	3	0	0
		OUT	20	6	0	1	2	1	0	0	0
07-Sep-02	17.00-18.00	IN	26	21	0	3	1	1	1	0	0
		OUT	34	22	0	1	5	1	2	0	0

	Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
Totals: (IN)	**197**	**118**	**0**	**18**	**38**	**10**	**17**	**5**	**0**
Totals: (OUT)	221	109	0	7	37	9	20	2	0

Road Traffic Survey, September 2002 - T5 Main Road (Muchinshi)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
08-Sep-02	06.00-07.00	IN	11	0	0	1	0	0	2	0	0
		OUT	10	2	0	0	0	0	0	0	0
08-Sep-02	07.00-08.00	IN	14	3	0	1	0	0	0	0	0
		OUT	4	8	0	0	0	0	0	0	0
08-Sep-02	08-00-09.00	IN	27	14	0	1	2	1	3	0	0
		OUT	27	10	0	0	5	0	0	1	0
08-Sep-02	09.00-10.00	IN	38	19	0	1	4	1	1	0	0
		OUT	24	12	0	0	1	0	1	1	0
08-Sep-02	10.00-11.00	IN	45	20	0	3	2	0	2	1	0
		OUT	90	14	0	2	4	0	1	0	0
08-Sep-02	11.00-12.00	IN	25	14	0	1	5	0	0	0	0
		OUT	19	15	0	2	2	1	2	0	0
08-Sep-02	12.00-13.00	IN	23	11	0	0	0	0	0	2	0
		OUT	17	13	0	1	3	1	0	0	0
08-Sep-02	13.00-14.00	IN	41	15	0	2	4	1	1	1	0
		OUT	33	4	0	0	4	1	2	0	0
08-Sep-02	14.00-15.00	IN	63	9	0	1	1	3	0	0	0
		OUT	34	13	0	0	2	0	4	0	0
08-Sep-02	15.00-16.00	IN	44	23	0	0	1	0	0	0	0
		OUT	25	15	0	2	5	1	2	0	0
08-Sep-02	16.00-17.00	IN	31	21	0	1	3	0	1	0	0
		OUT	36	21	0	4	7	1	3	1	0
08-Sep-02	17.00-18.00	IN	20	11	0	1	2	0	0	0	0
		OUT	17	16	0	0	4	2	1	0	0

	Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
Totals: (IN)	**382**	**160**	**0**	**13**	**24**	**6**	**10**	**4**	**0**
Totals: (OUT)	336	143	0	11	37	7	16	3	0

Road Traffic Survey, September 2002 - T5 Main Road (Chingola - Solwezi T Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
02-Sep-02	06.00-07.00	IN	0	1	0	0	1	0	1	0	0
		OUT	0	1	0	0	1	0	1	0	0
02-Sep-02	07.00-08.00	IN	1	1	0	0	1	0	3	0	0
		OUT	4	2	0	0	2	0	2	0	0
02-Sep-02	08-00-09.00	IN	0	0	0	0	5	0	3	0	0
		OUT	0	1	0	1	6	0	3	1	0
02-Sep-02	09.00-10.00	IN	0	1	0	1	3	2	4	0	0
		OUT	0	0	0	2	4	0	1	0	0
02-Sep-02	10.00-11.00	IN	3	0	0	0	7	1	1	1	0
		OUT	1	0	0	0	6	2	1	0	0
02-Sep-02	11.00-12.00	IN	0	0	0	3	3	0	6	1	0
		OUT	0	1	0	1	8	1	4	0	0
02-Sep-02	12.00-13.00	IN	1	1	0	0	6	0	3	0	1
		OUT	0	2	0	1	5	0	1	0	0
02-Sep-02	13.00-14.00	IN	2	1	0	0	7	3	3	1	0
		OUT	1	1	0	1	7	2	2	0	0
02-Sep-02	14.00-15.00	IN	1	1	0	3	4	0	4	0	0
		OUT	0	0	0	0	3	1	1	0	0
02-Sep-02	15.00-16.00	IN	2	1	0	1	1	1	1	0	0
		OUT	0	0	0	0	6	2	2	2	0
02-Sep-02	16.00-17.00	IN	1	0	0	1	8	2	3	0	0
		OUT	0	1	0	0	10	1	3	0	0
02-Sep-02	17.00-18.00	IN	2	1	0	1	7	1	5	0	0
		OUT	1	1	0	3	5	3	2	0	0

	Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
Totals: (IN)	**13**	**8**	**0**	**10**	**53**	**10**	**37**	**3**	**1**
Totals: (OUT)	7	10	0	9	63	12	23	3	0

Road Traffic Survey, September 2002 - T5 Main Road (Chingola - Solwezi T Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
03-Sep-02	06.00-07.00	IN	0	0	0	1	2	0	1	0	0
		OUT	2	0	0	0	0	0	0	0	0
03-Sep-02	07.00-08.00	IN	0	0	0	0	10	0	3	0	0
		OUT	1	1	0	1	3	2	2	0	0
03-Sep-02	08-00-09.00	IN	0	0	0	2	5	0	8	0	0
		OUT	4	0	0	1	4	0	1	1	0
03-Sep-02	09.00-10.00	IN	2	2	0	1	5	3	7	0	0
		OUT	0	1	0	0	5	2	3	0	0
03-Sep-02	10.00-11.00	IN	0	0	0	2	8	1	4	0	0
		OUT	0	1	0	0	10	0	4	0	0
03-Sep-02	11.00-12.00	IN	1	2	0	1	11	2	3	1	0
		OUT	1	0	0	1	7	0	4	0	0
03-Sep-02	12.00-13.00	IN	3	0	0	1	11	0	5	0	0
		OUT	0	1	0	0	6	0	6	0	0
03-Sep-02	13.00-14.00	IN	5	1	0	2	6	1	6	1	0
		OUT	1	0	0	2	4	1	4	0	0
03-Sep-02	14.00-15.00	IN	2	0	0	1	10	2	4	0	0
		OUT	1	1	0	0	5	0	3	0	0
03-Sep-02	15.00-16.00	IN	0	0	0	0	5	0	3	0	0
		OUT	0	1	0	4	6	1	5	0	0
03-Sep-02	16.00-17.00	IN	1	1	0	1	6	1	6	0	0
		OUT	1	0	0	1	8	2	6	0	0
03-Sep-02	17.00-18.00	IN	2	1	0	2	4	0	3	0	0
		OUT	0	1	0	0	6	2	4	0	0

	Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
Totals: (IN)	16	7	0	14	83	10	53	2	0
Totals: (OUT)	**11**	**7**	**0**	**10**	**64**	**10**	**42**	**1**	**0**

Road Traffic Survey, September 2002 - T5 Main Road (Chingola - Solwezi T Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
04-Sep-02	06.00-07.00	IN	2	1	0	0	3	0	0	0	0
		OUT	0	0	0	0	0	0	1	0	0
04-Sep-02	07.00-08.00	IN	0	0	0	0	4	0	3	0	0
		OUT	2	0	0	0	8	0	3	0	0
04-Sep-02	08-00-09.00	IN	0	0	0	0	7	0	9	0	0
		OUT	1	0	0	0	4	2	1	0	0
04-Sep-02	09.00-10.00	IN	0	1	0	1	4	1	6	0	0
		OUT	0	0	0	0	7	1	1	0	0
04-Sep-02	10.00-11.00	IN	0	0	0	0	5	0	8	1	0
		OUT	0	0	0	1	4	1	5	0	0
04-Sep-02	11.00-12.00	IN	2	0	0	0	5	1	5	0	0
		OUT	0	1	0	0	10	0	5	0	0
04-Sep-02	12.00-13.00	IN	0	1	0	1	4	0	6	2	0
		OUT	1	0	0	1	7	0	7	0	0
04-Sep-02	13.00-14.00	IN	0	0	1	0	6	2	3	0	0
		OUT	0	0	0	0	4	1	1	0	0
04-Sep-02	14.00-15.00	IN	0	3	0	0	8	1	4	0	0
		OUT	5	1	1	2	3	0	5	0	0
04-Sep-02	15.00-16.00	IN	0	0	0	1	5	0	7	0	0
		OUT	2	3	0	0	7	4	7	0	0
04-Sep-02	16.00-17.00	IN	2	0	0	0	4	1	4	0	0
		OUT	0	0	0	0	5	0	4	0	0
04-Sep-02	17.00-18.00	IN	0	1	0	2	8	1	3	0	0
		OUT	0	0	0	3	11	1	4	1	0
		Totals: (IN)	**6**	**7**	**1**	**5**	**63**	**7**	**58**	**3**	**0**
		Totals: (OUT)	**11**	**5**	**1**	**7**	**70**	**10**	**44**	**1**	**0**

Road Traffic Survey, September 2002 - T5 Main Road (Chingola - Solwezi T Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
05-Sep-02	06.00-07.00	IN	6	2	0	0	0	0	1	0	0
		OUT	6	2	0	0	0	0	1	0	0
05-Sep-02	07.00-08.00	IN	4	1	0	0	3	0	2	1	0
		OUT	4	1	0	0	3	0	2	1	0
05-Sep-02	08-00-09.00	IN	0	0	0	1	4	1	2	1	0
		OUT	0	0	0	1	4	1	2	1	0
05-Sep-02	09.00-10.00	IN	0	0	0	0	6	0	2	0	0
		OUT	0	0	0	0	6	0	2	0	0
05-Sep-02	10.00-11.00	IN	0	2	0	2	6	1	3	0	0
		OUT	0	2	0	2	6	1	3	0	0
05-Sep-02	11.00-12.00	IN	0	1	0	0	6	0	6	0	0
		OUT	0	1	0	0	6	0	6	0	0
05-Sep-02	12.00-13.00	IN	0	0	0	2	4	0	3	0	0
		OUT	0	0	0	2	4	0	3	0	0
05-Sep-02	13.00-14.00	IN	7	0	0	0	6	0	2	0	0
		OUT	7	0	0	0	6	0	2	0	0
05-Sep-02	14.00-15.00	IN	0	0	0	1	7	0	3	1	0
		OUT	0	0	0	1	8	0	3	1	0
05-Sep-02	15.00-16.00	IN	0	1	0	4	6	2	5	0	0
		OUT	0	1	0	4	6	2	5	0	0
05-Sep-02	16.00-17.00	IN	0	1	0	2	7	2	4	0	0
		OUT	0	1	0	2	7	2	4	0	0
05-Sep-02	17.00-18.00	IN	2	1	0	1	8	5	4	0	0
		OUT	2	1	0	1	8	5	4	0	0
		Totals: (IN)	**19**	**9**	**0**	**13**	**63**	**11**	**37**	**3**	**0**
		Totals: (OUT)	**19**	**9**	**0**	**13**	**64**	**11**	**37**	**3**	**0**

Road Traffic Survey, September 2002 - T5 Main Road (Chingola - Solwezi T Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
06-Sep-02	06.00-07.00	IN	0	0	0	1	3	0	0	0	0
		OUT	11	0	0	1	0	0	0	0	1
06-Sep-02	07.00-08.00	IN	0	0	0	1	7	0	4	0	0
		OUT	13	1	0	1	3	0	2	0	0
06-Sep-02	08-00-09.00	IN	1	0	0	0	2	0	5	0	0
		OUT	5	0	0	1	9	0	0	1	0
06-Sep-02	09.00-10.00	IN	2	1	0	2	5	2	4	1	0
		OUT	0	1	0	0	7	1	3	0	0
06-Sep-02	10.00-11.00	IN	2	0	0	0	8	2	3	0	0
		OUT	0	1	0	1	4	0	1	0	0
06-Sep-02	11.00-12.00	IN	13	0	0	1	3	0	4	0	0
		OUT	1	0	0	0	6	1	2	0	0
06-Sep-02	12.00-13.00	IN	11	0	0	3	8	0	1	1	0
		OUT	0	0	0	0	3	0	2	0	0
06-Sep-02	13.00-14.00	IN	0	0	0	0	10	3	3	1	0
		OUT	2	0	0	4	4	2	4	0	0
06-Sep-02	14.00-15.00	IN	2	0	0	1	6	2	0	0	0
		OUT	0	0	0	3	8	0	2	0	0
06-Sep-02	15.00-16.00	IN	4	0	0	1	4	1	2	0	0
		OUT	0	1	0	1	6	3	3	0	0
06-Sep-02	16.00-17.00	IN	0	1	0	1	9	1	4	0	0
		OUT	0	0	0	2	8	1	2	0	0
06-Sep-02	17.00-18.00	IN	1	1	0	0	7	1	1	0	0
		OUT	0	1	0	1	10	0	2	0	0
		Totals: (IN)	**36**	**3**	**0**	**11**	**72**	**12**	**31**	**3**	**0**
		Totals: (OUT)	32	5	0	15	68	8	23	1	1

Road Traffic Survey, September 2002 - T5 Main Road (Chingola - Solwezi T Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
07-Sep-02	06.00-07.00	IN	0	1	0	2	6	0	4	3	0
		OUT	9	1	0	0	2	0	0	1	0
07-Sep-02	07.00-08.00	IN	2	0	0	0	13	0	1	0	0
		OUT	4	0	0	0	5	0	1	0	0
07-Sep-02	08-00-09.00	IN	1	0	0	0	3	0	4	0	0
		OUT	1	2	0	1	4	0	4	0	0
07-Sep-02	09.00-10.00	IN	0	2	0	3	11	3	5	0	0
		OUT	0	0	0	2	9	1	2	1	0
07-Sep-02	10.00-11.00	IN	5	0	0	1	14	0	4	0	0
		OUT	1	0	0	1	3	1	3	0	0
07-Sep-02	11.00-12.00	IN	11	2	0	3	8	2	4	0	0
		OUT	0	0	0	3	4	2	5	0	0
07-Sep-02	12.00-13.00	IN	1	0	0	2	10	1	1	2	0
		OUT	1	0	0	3	14	1	2	0	0
07-Sep-02	13.00-14.00	IN	1	0	0	1	10	5	4	0	0
		OUT	0	1	0	1	4	0	3	0	0
07-Sep-02	14.00-15.00	IN	0	1	0	2	7	1	2	0	0
		OUT	0	0	0	1	7	1	1	0	0
07-Sep-02	15.00-16.00	IN	1	1	0	0	10	1	2	0	0
		OUT	0	1	0	0	12	3	7	1	0
07-Sep-02	16.00-17.00	IN	0	0	0	0	7	0	5	0	0
		OUT	0	0	0	1	11	2	4	0	0
07-Sep-02	17.00-18.00	IN	1	0	0	3	4	1	3	0	0
		OUT	0	1	0	1	15	0	4	0	0
		Totals: (IN)	**23**	**7**	**0**	**17**	**103**	**14**	**39**	**5**	**0**
		Totals: (OUT)	16	6	0	14	90	11	36	3	0

Road Traffic Survey, September 2002 - T5 Main Road (Chingola - Solwezi T Junction)

Date	Time	In or Out of Area	Description								
			Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
08-Sep-02	06.00-07.00	IN	0	2	0	1	1	0	2	0	0
		OUT	0	0	0	0	1	0	0	0	2
08-Sep-02	07.00-08.00	IN	0	0	0	1	4	0	5	0	0
		OUT	6	1	0	0	1	0	0	0	0
08-Sep-02	08-00-09.00	IN	2	2	0	1	6	1	2	0	0
		OUT	0	0	0	0	3	0	1	1	0
08-Sep-02	09.00-10.00	IN	3	0	0	3	4	2	2	0	0
		OUT	0	0	0	0	4	0	1	0	0
08-Sep-02	10.00-11.00	IN	2	1	0	1	5	1	0	0	0
		OUT	0	0	0	1	5	1	2	1	0
08-Sep-02	11.00-12.00	IN	0	0	0	2	13	0	0	1	0
		OUT	0	0	0	1	4	0	2	0	0
08-Sep-02	12.00-13.00	IN	6	0	0	0	7	0	3	1	0
		OUT	0	1	0	4	5	3	4	0	0
08-Sep-02	13.00-14.00	IN	2	0	0	2	2	1	2	0	0
		OUT	0	0	0	5	4	1	2	0	0
08-Sep-02	14.00-15.00	IN	0	0	0	0	4	3	0	0	0
		OUT	2	0	0	3	3	1	2	0	0
08-Sep-02	15.00-16.00	IN	4	1	0	4	3	4	3	0	0
		OUT	0	1	0	3	4	1	2	0	0
08-Sep-02	16.00-17.00	IN	0	0	0	1	8	0	2	0	0
		OUT	0	1	0	1	13	6	8	0	0
08-Sep-02	17.00-18.00	IN	0	0	0	1	8	2	1	0	0
		OUT	1	0	0	7	9	3	2	0	0

	Pedestrian	Bicycle	Motorcycle	Car	4WD	Mini-Bus	Truck	Coach	Tractor
Totals: (IN)	**19**	**6**	**0**	**17**	**65**	**14**	**22**	**2**	**0**
Totals: (OUT)	9	4	0	25	56	16	26	2	2